Health in the late pre-colonial and early colonial period in the Philippines

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Abstract

Bioarchaeology, the study of skeletal remains from archaeological sites, is useful in understanding the health of past populations. Information on health of past populations is important in a holistic interpretation of the past and also helps in understanding the current health trends within a population. The use of a biocultural approach in bioarchaeology is essential in understanding the interactions between culture and biology and how it affects the way people live. In Southeast Asia, bioarchaeological studies on prehistoric health have been accomplished in recent years. This improvement in the bioarchaeological literature of Southeast Asia has provided essential information about the past life of Southeast Asians. However, these studies are mainly focused on continental Southeast Asia while studies on skeletal remains from island Southeast Asia focus on origins of current populations and paleoanthropological research. This thesis aims to address the gap in bioarchaeological literature in island Southeast Asia by examining several skeletal samples for evidence of health and disease from the pre-colonial and colonial period in the Philippines.

The individuals from the Philippines were assessed for age and sex. The prevalence of skeletal and oral pathologies of the individuals from the two time periods were analyzed and compared. A summary of the archaeological and historical background of Southeast Asia and the Philippines was presented to provide a context of the samples. A review of the diseases likely to be seen in skeletal remains from the Philippines and the lesions they produce was also accomplished.

The individuals from the colonial period had a higher prevalence of both skeletal and oral pathologies, suggesting a decline in health with the onset of colonialism. This result is consistent with historical evidence indicating a decline in health among Filipinos during the early colonial period. A comparison of pathologies from the pre-colonial period to similar time periods in mainland Southeast Asia indicates that the individuals from island Southeast Asia had better health and were subjected to less stress than those from the continental region. The archaeological and historical background of both regions suggests a difference in lifestyle which had most probably contributed to the difference in health status of the individuals from continental and island Southeast Asia. However, the examination of more skeletal samples is needed to further assess this difference in health among individuals from the two regions.
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Chapter 1 – INTRODUCTION

Introduction

The prehistoric period of Southeast Asia involves a complex series of events which led to the spreading out of people throughout the region, with each country developed through different processes and influences that shaped their culture as it is today. Although great strides in the understanding of Southeast Asian prehistory have been made in recent years, there still remains a lot to be accomplished regarding the comprehension of the complexity of the prehistory in this region. Therefore, a review of the general prehistory of the region is essential in the interpretation of studies of skeletal remains from Southeast Asia.

Bioarchaeology refers to the study of human skeletal remains from archaeological sites (Larsen 1997; Buikstra and Beck 2006; Oxenham and Tayles 2006; Agarwal and Glencross 2011). It is useful in understanding the past since direct evidence from human remains are used in analyzing lifestyle, activities and health of past populations (Larsen 1997; Buikstra and Beck 2006; Agarwal and Glencross 2011). A biocultural approach is used in bioarchaeological studies to understand how the interactions between culture and biology affect the way people lived (Buikstra and Beck 2006; Agarwal and Glencross 2011). Bioarchaeological studies within Southeast Asia have progressed greatly during recent years, and more information regarding the life of past populations from Southeast Asia, particularly in the continental region, has been presented. However, more work still needs to be done particularly since most of the bioarchaeological studies in Southeast Asia have focused on sites from the continental region. Bioarchaeological literature on skeletal remains from island Southeast Asia is very sparse, with most focusing on descriptive reports of burials found from archaeological sites particularly those from earlier time periods. This thesis aims to contribute bioarchaeological information on island Southeast Asia by analyzing human skeletal remains from the Philippines to reduce this gap in knowledge and to provide a more holistic picture of the life of prehistoric populations from Southeast Asia. The study of overall health through the analysis of skeletal and dental remains, together with the ethnohistoric and archaeological studies on Philippine prehistory, can provide a more holistic picture of the past. Skeletal analysis is important for cross-examination of ethnohistoric and archaeological data in the interpretation of Philippine prehistory and early history.
The examination of skeletal remains from the Philippines helps in addressing the gaps in bioarchaeological literature of Southeast Asia by providing a representation of individuals from island Southeast Asia. In this thesis, skeletal samples dated to the pre-colonial Metal Age period and the early colonial period are studied and evidence of skeletal and dental pathologies were recorded systematically to assess any differences in the prevalence of these pathologies according to age and sex within and between the samples. Most studies on the health and lifestyle of prehistoric and early historic Filipinos are based mainly on ethnographic and historical accounts in addition to archaeological analysis of various artifacts from archaeological sites. On the other hand, recent analyses on prehistoric health in other parts of Southeast Asia are focused on the examination of human skeletal and dental remains (Tayles 1996; Tayles et al. 2000; Domett 2001; Nelsen et al. 2001; Krigbaum 2003; Pietrusewsky and Tsang 2003; Tayles and Buckley 2004; Matsumura and Hudson 2005; Domett and Tayles 2006b; Halcrow and Tayles 2008) as well as archaeological information. These studies have yielded a very significant amount of information on health and lifestyles of these people.

Regional and Temporal Context

Southeast Asia is comprised of several countries with diverse ecology and cultural identities. The region, which lies to the east of India, to the west of Oceania and below East Asia, has a very complex prehistory and history. Southeast Asia is divided into two geographic regions: continental or mainland Southeast Asia and island or peninsular Southeast Asia. Continental Southeast Asia refers to the countries that are part of the Asian continent while island Southeast Asia refers to the group of islands to the east and south of the South China Sea. These two regions have different local environments and histories which are reflected in the diversity of ethnicities and languages that can be found in the region (Harrison 1955; Williams 1976; Bellwood 1978; Bellwood 1992b; Wolters 1999; Osborne 2000; Glover and Bellwood 2004; SarDesai 2010).
Prehistory in Southeast Asia refers to the large span of time from the initial human settlement within the region culminating in the development of agriculture and the spread of the so-called “Great Traditions” all over Southeast Asia (Harrison 1955; Williams 1976; Wolters 1999; Osborne 2000). The peopling of Southeast Asia is believed to have occurred at around the end of the Pleistocene, as evidenced by archaeological records of human occupation in the region (Bellwood 1978; Garcia 1979; Higham 1989a; Glover and Bellwood 2004). These people are thought to be mainly foragers and hunter-gatherers (Bellwood 1978; Garcia 1979; Glover and Bellwood 2004; Paz 2004). A later migration of people of Austronesian origin occurred at around 4000 years ago (Bellwood 1978; Bellwood et al. 1995; Oppenheimer 2003a; Bellwood 2004; Glover and Bellwood 2004; Tanudirjo 2004). It is hypothesized that they brought with them agricultural techniques which allowed for the growth of the population and the development of a more complex and stratified society (Bellwood 1978; Bellwood et al. 1995; Oppenheimer 2003a; Bellwood 2004; Glover and Bellwood 2004; Paz 2004; Tanudirjo 2004). It was during the height of these state kingdoms that Europeans came into contact with Southeast Asians. 

Events regarding European contact in Southeast Asia are also complex, with some countries being “discovered” earlier than others. The arbitrary division of areas in the region
by European colonizers also contributed to the complexity of Southeast Asian history. While the historic period of Southeast Asia offers interesting possibilities for research, more studies on human prehistory in Southeast Asia are undertaken. This is mainly due to the interest of most researchers in the prehistory of the region, which is concentrated mainly on the early settlement of humans. Also, due to the abundance of historical records and archaeological sites of the European contact period, it may not seem that there is a need to use bioarchaeology in interpreting Southeast Asian history. This is particularly true in the Philippines, where history starts at around the mid-16th century, which is quite early compared with other parts of Southeast Asia.

Since the Spaniards started to colonize the Philippines with the aim of spreading Catholicism throughout the islands, written records pertaining to pre-Spanish beliefs and ways of life were destroyed in order to dispel “barbaric” and “paganistic” traditions of the Filipinos. However, verbal accounts of folk stories were passed down through generations (Agoncillo 1969; Roces 1977; Agoncillo 1990). Also, the appropriation of some beliefs into the Catholic framework has helped preserve part of the Filipino culture before the arrival of Europeans (Agoncillo 1969; Roces 1977; Agoncillo 1990; Robertson and Blair 1993). Archaeological explorations have yielded several artifacts which provide few insights on the origins and activities of early prehistoric Filipinos (Fox 1970; Garcia 1979; Junker 1998; Solheim 2002; Paz 2004; Solheim 2006). In addition, more information about the late prehistory of the Philippines has become known through the research of historians, anthropologists and archaeologists. Several theories regarding the phases of Philippine prehistory have been proposed (Zamora 1967; Garcia 1979). It is known that the Philippines was part of the “Indianized” Southeast Asia through historic records, linguistic evidence and archaeological data (Cœdès 1968; Garcia 1979). “Indianized” Southeast Asia refers to the parts of the region where strong influences of Indian culture had prevailed (Cœdès 1968; Osborne 1997; Lukas 2004). This includes the majority of the Southeast Asian region; however Indian influences were much stronger in some areas, particularly in mainland Southeast Asia and Indonesia (Cœdès 1968; Lukas 2004). Islamic influence came later, and the arrival of the Spanish resulted in the decline of Islamic rule in the northern and central Philippines (Agoncillo 1969; Garcia 1979). Chiefdoms were also present in the numerous islands of the Philippines prior to European contact (Garcia 1979; Junker 1993; Junker 1998).

Recently, archaeological and ethnohistorical research on various sites in the Philippines has shed more light on the latter part of Philippine prehistory and the connections of prehistoric Filipinos to their various neighboring countries. However, a study on the general
health of prehistoric Filipinos using data from skeletal remains has yet to be done. Current archaeological research in the Philippines focuses mainly on early prehistory, particularly on the initial human settlement within the archipelago. As the human remains from earlier periods are less likely to be preserved, studies are centered more on the material culture of early prehistoric sites. However, studies on sites dated to the historic period also focus more on material artifacts associated with burials and other archaeological features, with very little research focusing on the human remains themselves. Research on these human remains offer the possibility of providing a different perspective on the history of the region, and even confirm or refute interpretations based on archaeological and historical data.

As noted earlier, there has been little research regarding human remains from island Southeast Asia. This may be attributed to the local environment of the area, where preservation of skeletal remains, particularly from earlier periods, is very poor (Solheim 1954; Dizon 1979c; Dizon 1979a; Cuevas 2003; Barker et al. 2011). Another reason might be due to political tensions which makes it difficult for researchers to gather data from some areas. Thus, studies on prehistory in these areas focus on evidence of human occupation such as lithics, shells and fossilized faunal remains which are usually much better preserved than human remains (Solheim 1964; Bacus 2004; Paz 2004; Barker et al. 2007; Higham et al. 2009). This lack of research creates a gap in the knowledge of Southeast Asian prehistory. Also, the dearth of research on the changes in health and lifestyle from the prehistoric period to the European contact period presents another gap in the knowledge of Southeast Asian bioarchaeology. Did the health and lifestyle of Southeast Asians change upon the arrival of the Europeans? Was the quality of life improved by the introduction of Western ideologies and knowledge? These are some of the questions that this research aims to address.

**Aims**

The aims of this thesis are as follows:

- To review the prehistory and early history of Southeast Asia, focusing on the bioarchaeology of the region and to identify where more research should be carried out
- To assess whether or not there were any changes in health during the onset of colonialism in the Philippines and to begin addressing research questions regarding the prehistory of island Southeast Asia
- To provide a preliminary study on the state of health of past populations in continental and island Southeast Asia
This study begins to lay the foundation on the study of health and general lifestyle in prehistoric and early historic Philippines. The examination of human remains from different islands in the Philippines helps in garnering insights on what stresses these people were exposed to and how their health changed through time. Skeletal analysis provides another data source which, when used along with the ethnohistoric and archaeological data, can enable us to utilize a multi-disciplinary approach in interpreting the past. Also, an initial analysis of these remains would facilitate an assessment of possible future studies using skeletal samples from the Philippines to acquire a more holistic interpretation of the past of the Southeast Asian region.

This research also seeks to demonstrate the potential value of research using skeletal samples from the Philippines. Due to its strategic location, the Philippines was colonized by three different nations; namely Spain, the United States of America and Japan. Among all Southeast Asian nations, the Philippines was colonized the most by Western nations. Because of this unique history, it would be worthwhile knowing if the occupations of different colonizers had different effects on the health and ways of living of Filipinos. Also, this study aims to initiate research on the changes in health among Southeast Asians during the historic period.

**Objectives**

In order to address the aims and research questions of this thesis, the following objectives will be carried out:

- To provide a review of the current bioarchaeological research within Southeast Asia
- To examine skeletal remains from the prehistoric and historic period of the Philippines, looking specifically at skeletal and oral pathologies and comparing the prevalence of these pathologies according to age and sex within and between the samples
- To compare the patterns of health of the skeletal samples from the Philippines to samples from other parts of Southeast Asia

**Limitations of the Study**

Most of the sites where the skeletal samples were recovered had a history of looting, thus the archaeological context of some of the remains were lost, which makes the temporal
aspect of interpretation complicated. However, the data gathered from these individuals is still helpful in the assessment of general health in late prehistoric and early historic times. Three weeks were allotted for the examination of all fifty individuals, hence these samples were only examined once and intraobserver error could not be tested. Also, since most of the literature on the archaeology of the Philippines is only available locally, access to these was limited.

There is a big variation in sample size among the different sites with some having significantly larger sample size than the others. The samples from Palawan and Mindoro are from approximately the same time period, while the sample from Quezon is from an earlier time period. Thus a temporal comparison of the difference in general health can be made, although the number of individuals from each time period is not equal. The distribution of individuals according to age and sex were also unequal and may not accurately represent the living population. While the samples from both time periods are rather small, any samples from this area are very few so it is worthwhile to examine all that can be possibly examined to at least have some representation of individuals from island Southeast Asia.

**Thesis Structure**

**Chapter 2**

The following chapter discusses the literature on the prehistoric and historic periods of Southeast Asia. The environmental background of prehistoric human settlements is examined in the next chapter to assess factors affecting human occupation within the region. Also included in the next chapter is a short synopsis on Philippine prehistory and early history to provide the context of the study gathered from ethnohistoric accounts and archaeological reports. The current state of bioarchaeology in Southeast Asia is assessed by reviewing recent articles, reports and other research publications related to bioarchaeology within the region. Studies on indicators of skeletal and oral health and disease in prehistoric Southeast Asia are reviewed. Debates on issues regarding the interpretation of health from skeletal remains are also addressed in this chapter.

**Chapter 3**

The third chapter provides a review of the archaeological context of the materials used in the study as well as the methodologies used in recording data. Archaeological contexts for each individual and the site in general were gathered through reports, field recording forms
and notes from previous excavations. General texts on paleopathology and other markers and indicators of stress and disease were consulted for methodological guidelines.

Chapter 4

The analysis of data collected in this study is presented in the fourth chapter.

Chapter 5

The fifth chapter discusses the analysis of the results presented in the fourth chapter and what can be inferred about past health based on these results. A discussion on the comparison of these results with other previously published reports on the health of prehistoric Southeast Asian populations is also included in this chapter. An assimilation of the results of the previous chapters to address the aims of this thesis is also presented in this chapter. Suggestions for further research and other recommendations are also discussed.
Chapter 2 – LITERATURE REVIEW

This chapter is divided into three main parts: Southeast Asian prehistory and early history, the prehistory and early history of the Philippines and Bioarchaeology in Southeast Asia. The first two sections give a synopsis on the context of the samples in regional and country-specific perspectives. The last section summarizes the current state of bioarchaeology in the region and outlines the recent advances in bioarchaeological research within Southeast Asia.

Southeast Asian Prehistory and Early History

To begin with, it is essential to provide a brief summary of the prehistory and history of the region to provide a context in which the remains examined could be situated. A comparison of samples from the same region can also be accomplished if an understanding of the regional context of the samples is achieved.

The term ‘Southeast Asia’ is a relatively recent construct – one that was formed during the Second World War – to describe a region that was “not India, nor China, nor part of the Pacific” (Osborne 1997, p.50). It is neither a distinct cultural entity nor a political unit, and different authors have used varying boundaries to describe this region. The formation of an Association of Southeast Asian Nations (ASEAN) has helped standardize the political boundaries of the region. However, scholars had varying views as to what constitutes Southeast Asia according to archaeological, linguistic and ethnohistoric perspectives (Bellwood 1978; Bellwood et al. 1995; Glover and Bellwood 2004; Solheim 2006).

Recent research on the pre-European past of Southeast Asia has shed some light on how the region was settled and how it became the Southeast Asia that is known presently. Through archaeological and ethnohistoric research, it has been inferred that the aboriginal settlers of Southeast Asia were of the ‘australoid’ phenotype and had a nomadic lifestyle (Harrison 1955; Williams 1976; Bellwood 1978; Wolters 1999; Osborne 2000). At present, however, studies are focused on the Austronesian migration to Southeast Asia and the Pacific as evidenced by the numerous archaeological, linguistic, and genetic reports on the subject (Solheim 1975; Blust 1980a; Blust 1980b; Solheim 1984-1985; Bellwood et al. 1995; Blust 1995; Melton et al. 1998; Gray and Jordan 2001; Blust 2002; Oppenheimer 2003a; Bellwood 2004; Oppenheimer 2004; Szabo and O’Connor 2004; Tanudirjo 2004; Adelaar and Pawley 2009; Peng et al. 2010; Spriggs 2011). Little research has been done on the prehistory of the
aboriginal people, the initial settlers of Southeast Asia. This is mainly due to the lack of archaeological evidence and the adoption by these people of the Austronesian language and culture (Cooper 1940; Garcia 1979; Bellwood 1985). Nevertheless, it has been hypothesized that the only members of Southeast Asian aborigines that have managed to keep their own language are the Andamanese aborigines, as all the other ‘australoid’ groups throughout Southeast Asia have adopted the Austronesian languages of the lowland people (Cooper 1940; Bellwood 1978; Garcia 1979; Bellwood 1985).

Austronesians refer to the ancestors of the majority of the current Southeast Asian population. Originally used exclusively for linguistics, the term ‘Austronesian’ is now adopted by other disciplines to refer to the people who speak Austronesian languages instead of just the language group (Bellwood 1978; Bellwood 1992b; Bellwood et al. 1995). The Austronesians were not the initial settlers of Southeast Asia. It is hypothesized that the increase in population enabled by the adoption of agriculture in Southern China and Taiwan led people to migrate further down to the Southeast Asian region (Shutler Jr. and Marck 1975; Bellwood et al. 1995; Blust 1995; Melton et al. 1998; Oppenheimer 2003a; Bellwood 2004; Oppenheimer 2004; Tanudirjo 2004; Liu 2007; Adelaar and Pawley 2009; Peng et al. 2010; Spriggs 2011). These people brought with them knowledge of agricultural techniques which enabled these populations to flourish and displace the initial settlers within the region (Adelaar and Pawley 2009). The current political boundaries of different Southeast Asian countries have been a result of recent history as well as the influence of pre-European states that flourished within the region (Osborne 2000; SarDesai 2010). In prehistory, people who had been living in the region had certain allegiances to their own leader, and thus considered themselves members of that particular state or kingdom. The boundaries of these kingdoms were fluid; the territorial boundaries of each kingdom were not exactly specified by land but by the people who support the leader of the state (Appadurai 1986; Bentley 1986). This type of state has been defined as a rippling or radiating state, and the core is where the most politically powerful people reside, with the state’s influence getting weaker as it reaches the periphery (Appadurai 1986; Bentley 1986; Kardulias 1999). However, the arrival and colonization of Southeast Asia by different European invaders has resulted in the delineation of boundaries according to land. Vietnam and parts of Laos and Cambodia were formerly known as French Indochina. Thailand, formerly known as Siam, had a wider territory than its current boundaries, and island Southeast Asia was very much fragmented according to the agreement of the different European colonizers (Harrison 1955; Williams 1976; Garcia 1979; Osborne 2000; SarDesai 2010). Indeed, the national identity of each country, though a
recently acquired concept, has been shaped by the prehistoric and historic processes that
governed this region.

Environment

Changes in the environment within the Southeast Asian region brought about by the
sea level, glacial and climate changes which occurred during the late Pleistocene to early
Holocene had an effect on the flora and fauna of the region (Bellwood 1990; Bellwood et al.
1995). It has been hypothesized that Southeast Asia, particularly island Southeast Asia, had
been reached by humans through land bridges that were present during the late Pleistocene
when sea levels were lower and parts of island Southeast Asia were still connected to the
mainland (Bellwood 1990). However, the climate change that occurred after the glacial
melting at the end of the last Ice Age brought about changes in the landscape of the region.
Changes in sea level have transformed coastlines within the region, particularly within island
Southeast Asia. Sites that had easy access to the coastline, and therefore to marine resources,
were now underwater and some sites where the sea level had regressed were pushed further
inland by these changes (Chappell and Shackleton 1986; Thiel 1987; Simanjuntak 2006;
Piccini and Iandelli 2011).

Southeast Asian climate and landscape is often lumped together as tropical with
seasonal monsoons. However, the topography of mainland Southeast Asia is quite different
from that of island Southeast Asia. Mainland Southeast Asia has an extensive land area
suitable for the development of agriculture while in island Southeast Asia, land for agriculture
is more limited (Maloney et al. 1989; Higham 1995; Higham and Lu 1998; Lape 2003;
Bellwood 2005). It has been argued that the vast lands available for food production in
mainland Southeast Asia was a key factor in the expansion of agricultural societies in the area
(Higham 1989a; Higham 1989b; Higham 2002a; Bellwood 2005). Island Southeast Asia, or
maritime Southeast Asia as it is otherwise identified in some texts (Cœdès 1968; Christie
1995), consists of numerous small islands which encouraged the development of a dynamic
maritime culture along with agriculture (Bellwood 1985; Lape 2003; Szabo and O’Connor
2004).

Southeast Asia lies within the tropics, and diverse flora and fauna can be found in the
region which cannot be seen anywhere. Most of the region is frequently subjected to
typhoons during the monsoon season, which is usually around June to September but can vary
depending on location and other environmental factors (Harrison 1955; Williams 1976;
Wolters 1999; Osborne 2000). This diversity in local environment and resources within
mainland and island Southeast Asia would have had different impacts on the health of people living in these two regions.

The abundant resources found near bodies of freshwater and coastal areas influenced the human settlement of Southeast Asia. Scholars have asserted that aboriginal people settled near major bodies of water before being driven further inland by Austronesian settlers (Bellwood 1978; Bellwood 1985; Kramer 1991; Solheim 2006). In the Philippines, historians have emphasized this lowland-upland division based on Spanish accounts of lowland and upland people (Garcia 1979; Agoncillo 1990; Robertson and Blair 1993). Spanish colonizers had managed to convert most of the people on lowland plains into Christianity while a separate group of people living in the mountains proved to be more resistant to their advances (Agoncillo 1969; Garcia 1979; Robertson and Blair 1993).

**Initial Settlers**

The initial settlement of Southeast Asia occurred during the middle to late Pleistocene (Bellwood 1978; Glover and Bellwood 2004; Szabo and O'Connor 2004). Fossils of hominids as well as other artifacts such as stone tools dated to as far back as the mid-Pleistocene indicated that the region was populated during this time.

Research on *Homo erectus* fossils discovered in Indonesia and China suggested that modern humans evolved from these people based on phenotypic characteristics observed from these fossils such as the shovel-shaped incisors (Harrison 1955; Williams 1976; Osborne 2000). Though some studies had proposed that the current populations of Asia and Southeast Asia developed from these *Homo erectus* populations (Wolpoff et al. 1984; Kramer 1991; Clark 1992; Ember et al. 2004), recent work on human DNA and evolutionary studies suggests that the modern human population spread from hominid populations in Africa instead of those found in Asia (Takahata 1995; Gibbons 1997; Jin et al. 2001; Oppenheimer 2003b; Jurmain et al. 2005; Willoughby 2007; Carrion et al. 2011). These studies support the so-called “Noah’s ark theory” or “replacement evolution” which proposes that although *Homo erectus* was able to travel to different parts of the world, they became extinct afterwards, thereby allowing the *Homo sapiens* from Africa to survive and populate the world (Howells 1976; Kramer 1991; Ember et al. 2004). This theory is opposed to the other alternative, the “candelabra theory” or “multiregional evolution” which proposes that the *Homo erectus* from Africa migrated to different parts of the world, and then evolved into *Homo sapiens* independently (Howells 1976; Kramer 1991; Ember et al. 2004). The remains of early hominids in Java (Modjokerto, Sangiran and Ngandong remains) and Beijing (Zhoukoudian,
Lantian and Gongwangling remains), which, based on their morphology seem to be closely related, had been discovered by archaeologists and were dated to be from as early as around 1.8 million years ago to as recent as 25,000 years ago (Clark 1992; Corvinus 2004; Jurmain et al. 2005; Igarashi and Mats'ura 2010). The earliest remainsof *Homo sapiens* in Southeast Asia so far have been found in Niah Cave in Sarawak, which was dated to about 40,000 years ago, and from Tabon Cave in Palawan, which dates to around 24,000 years ago (Fox 1970; Dizon et al. 2002; Detroit et al. 2004). An earlier date of around 67,000 years ago has been established on a metatarsal bone from Cagayan in Northern Luzon, Philippines, but whether the remains were from a modern human (*Homo sapiens*) or a hominid is still being debated (Mijares et al. 2010).

The region that is now classified as Southeast Asia was originally settled by the so-called ‘Negrito’ type and the ‘australoid’ type (Harrison 1955; Garcia 1979). These aboriginal people were thought to have come from Africa using land bridges during the middle to late Pleistocene and eventually arrived and settled in Southeast Asia (Harrison 1955; Garcia 1979). These people were also believed to be hunter-gatherers based mainly on archaeological evidence of human settlement during this period (Harrison 1955; Garcia 1979). Endemic terrestrial animals and local vegetation were the primary staples of their diet (Harrison 1955; Williams 1976; Garcia 1979). References to other aboriginal types such as the ‘Veddoid,’ a term which was sometimes used synonymously with Negrito, and the ‘Melanesoid,’ who were supposedly descendants of the Australoids and the Negrito or Veddoid, are seen in earlier texts but are not mentioned in later reports (Harrison 1955; Williams 1976). The Negritos are believed to have different origins than the majority of Southeast Asians today, who come from the Mongoloid stock (Bellwood 1978). It is also thought that they once had their own language, which was lost now that most groups have adopted the Austronesian languages of the lowland people, but might have survived in the case of the Andamanese Negritos (Bellwood 1978). The terms ‘Negrito,’ ‘Australoid,’ ‘Veddoid’ and ‘Melanesoid’ were used to refer to aboriginal people from different parts of Southeast Asia and near Oceania (Harrison 1955; Williams 1976; Garcia 1979). These people were different from the lowland settlers of Southeast Asia phenotypically and culturally, and were thus thought to be from a different origin by western scholars. However, since the basis of the usage of these terms is phenotypes, recent advances on the study of genetics have made these terms obsolete since phenotypic variation has been found to be the result of a combination of genetic and environmental factors (Jackson 1992; Taylor 1997; Gravlee 2009). Also, since the paradigm shift in anthropology from an ethnocentric unilineal
evolutionary perspective to a more cultural relativist perspective, these typological terms which have had ethnocentric connotations had become archaic and outdated (Taylor 1997).

These native settlers had initially populated the whole region but were pushed further inland with the beginning of Austronesian migration at around 5000 years ago (Adelaar and Pawley 2009). These Austronesian language and culture complex bearers started to populate the Southeast Asian region, eventually spreading out into mainland and island Southeast Asia as well as the Pacific (Bellwood et al. 1995; Szabo and O'Connor 2004). The so-called Neolithic culture complex were associated with these people, as are the innovations that led to the Metal Age (Bellwood et al. 1995).

The Austronesian Migration

Descendants of the Austronesians populate most of Southeast Asia today, with remnant aboriginal populations found mostly in mountainous terrains in island Southeast Asia (Bellwood et al. 1995; Szabo and O'Connor 2004). It is also generally agreed upon that the Austronesians brought with them the skills and techniques of agriculture, thus allowing for the population expansion which gave rise to many agrarian kingdoms of Southeast Asia (Bellwood et al. 1995; Lape 2003; Glover and Bellwood 2004). The Austronesian peoples were also hypothesized to be great maritime seafarers who spread from southern China to as far west as Madagascar and as far east as Easter Island. There are around 1000 to 1200 Austronesian languages, and this diversity is attributed not just to the diffusion of the language through borrowing, but also to the dispersal of the people using these languages (Blust 1976; Blust 1980b; Bellwood et al. 1995).

The Austronesian Migration Theory, or as other researchers call it, the “Out-of-Taiwan” or “Out-of-Asia” Theory, is the most widely accepted theory regarding human settlement in Southeast Asia (Shutler Jr. and Marck 1975; Tanudirjo 2004; Bellwood and Dizon 2005; Chiu and Sand 2007). The theory had its foundation in linguistics, but recent research on the Austronesians featured collaborations among the disciplines of archaeology, anthropology, biology and linguistics (Bellwood et al. 1995; Oppenheimer 2003a; Bellwood 2005; Spriggs 2011). The term ‘Austronesian’ was originally applied to the ancestral language of most Southeast Asians. Nowadays it is also used to refer to the people who spoke this ancestral language and whose population spread from South China and Taiwan and occupied the rest of Southeast Asia and Oceania (Bellwood 1978; Bellwood et al. 1995).
Several locations have been hypothesized as the ‘homeland’ of the Austronesian people. The most popular location is Taiwan (Shutler Jr. and Marck 1975; Bellwood et al. 1995; Glover and Bellwood 2004; Chiu and Sand 2007; Spriggs 2011), though some DNA evidence suggests otherwise (Li et al. 2008; Peng et al. 2010). Other locations include the east coast of mainland Southeast Asia and areas in island Southeast Asia such as the region within the southern Philippines, northwest Borneo and northern Sulawesi (Solheim 1996; Solheim 2006) as well as the area within eastern Indonesia, western New Guinea and the Bismarck archipelago (Chiu and Sand 2007).

Two models have been used to explain the Austronesian expansion based on archaeological, ethnohistoric and linguistic evidence (Bellwood 1996; Chiu and Sand 2007). The more popular model is the phylogenetic model, where shared cultural traits of different but related groups of people imply common ancestry (Bellwood 1996; Bellwood 2005; Chiu and Sand 2007). This model puts emphasis on “historical sequences of cultural differentiation or divergence within related groups” through different lines of evidence (Chiu and Sand 2007, p.30). These sequences are then interpreted to show a continuous tradition spread through the movement of humans from one place to another. The other model, ‘reticulation,’ emphasizes “intensive interactions” among different populations which results in having shared cultural traits (Bellwood 1996; Chiu and Sand 2007). This model argues that similar culture traits of different populations can be the result of a cultural co-evolution and does not necessarily mean that those populations have a single ancestor (Chiu and Sand 2007). Culture is formed through the complex interactions and stimulations within and outside societies which means that different groups with shared culture traits does not necessarily mean that those groups are biologically related (Chiu and Sand 2007).

Three main theories on the expansion of Austronesians throughout Southeast Asia and into Oceania have been proposed. The express train model, which relies heavily on linguistic evidence of Austronesian expansion, suggests that the Austronesian culture-bearers spread rapidly throughout Southeast Asia within a few thousand years (Blust 1980b; Bellwood et al. 1995; Gray and Jordan 2001; Oppenheimer 2004). However, archaeological evidence shows that Austronesian expansion might not be as rapid as suggested by the linguistic evidence, particularly the expansion into Oceania (Bellwood et al. 1995; Oppenheimer 2003a; Bellwood 2004; Oppenheimer 2004; Tanudirjo 2004; Spriggs 2007). Thus, the slow boat model was proposed as an alternative to the express train model (Bellwood et al. 1995; Diamond 2001; Oppenheimer and Richards 2001). More recent studies indicate that a combination of both models is more appropriate in explaining the expansion of Austronesians throughout
Southeast Asia and Oceania. The triple-I model, which stands for Intrusion, Integration, and Innovation, proposes that several factors made an impact on the speed of settlement of Southeast Asia and Oceania by Austronesians (Green 2003).

**Linguistic Evidence**

The reconstruction of an ancestral Austronesian language was done using a comparative-historical approach on the languages within the Austronesian language family (Blust 1976; Blust 1980a; Bellwood et al. 1995; Blust 1995; Adelaar and Pawley 2009). Cognates – words with the same meaning that are similar across languages except for a single letter or syllable – were compared to assess the shared innovations of each language group (Blust 1976; Blust 1980a; Blust 1980b; Blust 1981). Similarities of terms for different kinds of flora, fauna, natural phenomena, body parts and numbers among others were compared for the reconstruction of an Austronesian proto-language (Blust 2002; Adelaar and Pawley 2009). Common terms for pottery and metal imply the spread of Austronesians during the Neolithic to early Metal Age period (Blust 1976; Blust 1995; Adelaar and Pawley 2009). While it can be argued that languages can spread through contact with other cultures without human migration, the degree and manner of the diversity of the Austronesian language family suggests that human migration accompanied the language diffusion within the region (Bellwood et al. 1995; Blust 1995; Adelaar and Pawley 2009).

**Archaeological Evidence**

Research utilizing both archaeological and linguistic data pointed to Taiwan as the ‘homeland’ of the Austronesian people at around 5000 years ago (Blust 1976; Bellwood et al. 1995; Blust 1995; Oppenheimer 2003a; Bellwood 2004; Oppenheimer 2004; Tanudirjo 2004; Adelaar and Pawley 2009). These people were then hypothesized to have migrated, rather rapidly, to the rest of Southeast Asia as evidenced by the early dates of domesticated rice found in archaeological sites throughout Southeast Asia, particularly in island Southeast Asia (Higham 1995; Oppenheimer 2004; Szabo and O'Connor 2004; Tanudirjo 2004; Bellwood 2005; Higham et al. 2011). The “Express Train” model explains the hypothesis of the rapid movement of people from the Austronesian homeland to the rest of Southeast Asia which was occupied at around 4000 BP (Bellwood et al. 1995; Oppenheimer 2004). The presence of similar material culture in Neolithic sites within Southeast Asia also served as evidence of the expansion of Austronesians across the region. These artifacts included red-slipped pottery, distinct ‘Austronesian’ pottery decorations, the shape and form of the pottery, jade ornaments...
and evidence of rice domestication (Bellwood 1978; Bellwood 1985; Bellwood et al. 1995; Bellwood 2004; Oppenheimer 2004; Szabo and O'Connor 2004; Chiu and Sand 2007).

Central to the argument for the Austronesian expansion is the spread of agriculture, particularly the domestication of rice, within the region (Higham 1995; Bellwood 2005; Bacus et al. 2006; Higham et al. 2011). Agriculture in Southeast Asia is not limited to the lowland plains. Terracing of mountains for rice agriculture is common throughout Southeast Asia, and this can also be seen in China. It has been hypothesized based on archaeological findings that agricultural communities specializing in rice domestication first settled southern China and made their way to Taiwan (Bellwood 1978; Bellwood et al. 1995; Glover and Bellwood 2004; Bellwood 2005). The rapid increase in population of these agriculturalists allowed for a swift settlement of the region. Similarities in other artifacts such as pottery and stone tools suggests a north-to-south expansion of the Austronesians (Bellwood et al. 1995; Glover and Bellwood 2004). Domesticated animals such as dogs, pigs, chickens and cattle were also present in the archaeological record as well as the water-buffalo, which has been instrumental in the maintenance of rice fields (Bellwood et al. 1995; Bacus et al. 2006; Piper et al. 2011).

**Biological Evidence**

Studies on mitochondrial DNA and paternal lineages of present-day Southeast Asians suggested different possible origins of the current population. Some studies on mitochondrial DNA agreed with the Out-of-Taiwan hypothesis (Melton et al. 1998; Lertrit et al. 2008; Tabbada et al. 2010) though some research has claimed the dates for the Austronesian expansion was earlier than the proposed dates based on archaeological studies (Hill et al. 2007). Other research has argued for a southern Chinese origin instead of Taiwan (Li et al. 2008), while yet another study has concluded that the spread of Austronesian culture particularly in mainland Southeast Asia was due to a cultural diffusion and not through human migration (Peng et al. 2010).

Since studies on Austronesian origins using DNA evidence is fairly recent, more research is needed in order to gain conclusive results. The differences in the methods and analysis of biological evidence has given support to different theories regarding Austronesian migration, and reconciling these differences may give a more definitive answer on the origins of modern Southeast Asians. Bioarchaeological studies on Southeast Asian origins through skeletal and dental morphometric analyses have shown the population history of Southeast Asians (Hanihara 2006; Matsumura 2006; Pietrusewsky 2006). The differences in skeletal
morphology throughout the region also suggest a north-to-south expansion of Austronesians (Bulbeck and Lauer 2006; Hanihara 2006; Matsumura 2006; Pietrusewsky 2006).

The Nusantao Maritime Trading and Communication Network

An alternative to the more popular Austronesian Migration theory was proposed by Wilhelm Solheim II (Solheim 1975; Solheim 1984-1985; Solheim 1996; Solheim 1999; Solheim 2000; Solheim 2006). The Nusantao hypothesis argues that there was a south-to-north movement of people based on archaeological artifacts found in the region (Solheim 1996; Solheim 2000). Solheim hypothesized that the ancestors of the majority of Southeast Asians today, whom he called the ‘Nusantao,’ originated from the region of southern Philippines and northern Indonesia (Solheim 1984-1985; Solheim 1996; Solheim 2000). He also argued that these people were seasoned maritime travellers with extensive trading and communication networks throughout the rest of Southeast Asia and even extending to China, Korea and Japan (Solheim 1984-1985; Solheim 2006). The Nusantao, defined by Solheim as the ‘natives’ of Southeast Asia, are described as the coastal settlers who had developed far-reaching networks that allowed for the diffusion of the Austronesian language and the Nusantao culture complex (Solheim 1984-1985; Solheim 2006). He claims that the Nusantao do not have a concept of having a single culture or state (Solheim 2006). The people living further inland were not considered as Nusantao (Solheim 2006). The Nusantao Maritime Trading and Communication Network refers to a specialized maritime organization of the Nusantao people which extends to the whole of Southeast Asia and as far north as Korea and Japan (Solheim 2006).

Solheim (1996) defined the term Austronesian as purely linguistic, and that this language was spread by the Nusantao, who had already settled within Southeast Asia. He maintained that the usage of the term ‘Austronesian’ to describe a group of people or culture is inappropriate (Solheim 1975; Solheim 1996). He argued that the networking of these people helped spread the Austronesian language and not through the actual migration of people (Solheim 1996; Solheim 2006). Evidence cited to support his claim included the presence of double burial jars found in Korea and Palawan & Batanes in the Philippines, table and capstone dolmens found in Korea and Japan which can also be found in Assam and Taiwan, and evidence from physical anthropologists claiming that pre-Jomon Japanese have Southeast Asian ancestors (Solheim 1975; Solheim 1984-1985; Solheim 1996; Solheim 2006). He described four lobes of the Nusantao Maritime Trading Network, with the central lobe as the original lobe, which then spread to northern, western and eastern lobes. The
central lobe was dated to a “few hundred years before 5000 BCE” (Solheim 2006, p.50), while the northern lobe was dated to around 5000 BCE and the western lobe to around 2500 BCE (Solheim 2006).

Many scholars disagree with this hypothesis, citing archaeological, biological and linguistic evidences supporting the Austronesian Migration Theory and the north-to-south expansion of Southeast Asian ancestors (Blust 1976; Blust 1980a; Blust 1980b; Bellwood et al. 1995; Blust 1995; Melton et al. 1998; Jin et al. 2001; Bellwood 2004; Spriggs 2007; Lertrit et al. 2008). However, some evidence from mitochondrial DNA has supported the Nusantao hypothesis (Peng et al. 2010).

**The Development of Southeast Asian States**

Typically defined as the “classical period” of Southeast Asia, the development of the great Southeast Asian states was marked with numerous megalithic structures and narratives of the conquests of these great empires were passed down through generations (Harrison 1955; Williams 1976; Osborne 2000). Great agrarian kingdoms were developed in Mainland Southeast Asia during late prehistory. These kingdoms grew in size due to the surplus resources from intensified agriculture. The unique landscape allowed for food staples such as
rice to flourish, which led to the formation of these complex hierarchies and megalithic structures, the remnants of which can still be seen today. In island Southeast Asia, maritime empires were formed instead of agrarian kingdoms due to the geography of this region, with the seas serving as a highway for these kingdoms to conduct trade and sometimes pillage one another (Lape 2002; Lape 2003). It was during this time that trade and exchange among Indian and Chinese kingdoms flourished, consequently diffusing elements of Indian and Chinese culture to Southeast Asia. Most indigenous scripts in Southeast Asia, like the indigenous scripts of Thailand, Laos, Myanmar and the Philippines, have Sanskrit and Arabic influences (Postma 1991). Also, the religion of the majority of people from Southeast Asia except the Philippines originated from China and India. In Vietnam, Laos, Myanmar, and Thailand, Buddhism, which had its origins in India, has been the religion of the majority (Harrison 1955; Williams 1976; Wolters 1999; Osborne 2000). Islam, which spread through southern India from the Middle East, is widespread in Malaysia, Indonesia and the southern Philippines. It is only the Philippines, which were under Spanish rule for more than 300 years, where a Western religion, Catholicism, is the prevailing religion. “Indianized States” such as the Ayutthaya and the Khmer Empires of Mainland Southeast Asia, and the Srivijaya and Madjapahit Empires of island Southeast Asia, were heavily influenced by Indian culture, which was apparent from their religion and social hierarchy (Wolters 1999; Osborne 2000). Social hierarchy of prehistoric Southeast Asia was also influenced greatly by Indian culture, with the segregation of the elite, the religious leaders, commoners and slaves (Osborne 2000). Chinese influence was less apparent, with some loanwords and Chinese philosophy such as Confucianism and Taoism as evidence of cultural diffusion through contact with the Chinese (Harrison 1955; Williams 1976; Wolters 1999; Osborne 2000). Chinese settlements in Thailand, Malaysia, and to a lesser extent the Philippines, have contributed to the multiculturalism of these countries, though members of these settlements primarily speak their own native Chinese language and English rather than the indigenous language of the country.

Though elements of Indian and Chinese influence are evident in many Southeast Asian cultures, each country has their own distinct identities, with most having “indigenized” foreign customs to fit their own (Wolters 1999). Distinct Austronesian culture traits that are neither Indian nor Chinese can be found among Southeast Asian cultural traditions such as folk stories, epics and poems, and cultural practices such as tattoo application as a symbol of high status (Harrison 1955; Agoncillo 1969; Williams 1976; Gibson 1990; Robertson and Blair 1993; Osborne 1997; Osborne 2000). However, as Southeast Asia is between two
‘Great Traditions’, Southeast Asian culture is often summed up as ‘little India’ or ‘little China,’ which is considered inappropriate by many scholars (Harrison 1955; Williams 1976; Bellwood 1978; Wolters 1999; Osborne 2000).

Mainland Southeast Asia – The Agrarian Kingdoms

Current accepted theories propose that the advancement of agriculture made population growth possible, therefore giving way to the development of culture, social customs and behavior, and finally hierarchy within a social group (Bellwood 2005). The large, structured prehistoric metropolitan areas built in Cambodia, Vietnam, and Thailand serves as evidence of the power of agriculture to build and destroy empires (Wolters 1999; Osborne 2000; SarDesai 2010). The huge amount of people living in these prehistoric cities can only be supported by a surplus of food, and the production of food through agriculture has enabled people to not only develop a sedentary lifestyle, but also to foster culture and social complexity as seen by these megalithic creations. It is known through archaeological data and ethnohistoric accounts that these populations were heavily reliant on agriculture for their main food source, and had developed unique methods and equipment for irrigation and maintenance of rice fields (Bellwood 1992a; Taylor 1992; Higham 1995; O'Connor 1995; Wolters 1999; Bellwood 2005).

A classic example of an agrarian kingdom is the Khmer Empire in mainland Southeast Asia, whose height of power was achieved at around the 12th century AD (Harrison 1955; Williams 1976; Taylor 1992; Osborne 2000). The main seat of power of the Khmer Empire was located in present-day Cambodia, with their influence extending to parts of present-day Laos, Thailand, Vietnam and Myanmar during the empire’s peak of political power (Harrison 1955; Williams 1976; Taylor 1992; Wolters 1999; Osborne 2000). Agriculture served as the base for military expansion and the construction of elaborate temples, the ruins of which can still be seen today (Taylor 1992; Wolters 1999). Innovations in irrigation meant a higher crop yield, which was essential as the empire acquired more land, and thus more people. At the height of the Khmer Empire, the kingdom ruled over all of present-day Cambodia, parts of Southern Vietnam and Southern Laos as well as vassal states in Thailand (Taylor 1992; Osborne 2000). The megalithic structures in Angkor present a remarkable mix of Hindu and Buddhist elements, suggesting the differences in preferred religion by the different leaders during their reign (Taylor 1992; Osborne 2000). Another example of an agrarian kingdom is the Ayutthaya Empire in Thailand which reigned from the mid-12th century to the 16th century AD (Taylor 1992).
The dynamics of mainland Southeast Asian states was rather different from their counterparts in island Southeast Asia. Though both have elements of hierarchy, the degree and implementation of this hierarchy was quite different. In mainland Southeast Asia, conquered kingdoms such as the Haripunjaya in central Thailand and several Champa territories which were occupied by the Khmer Empire were subsumed under the conqueror’s rule, and answered directly to the leader of the dominant state (Taylor 1992; Wolters 1999; Osborne 2000). Neighboring states were often under conflict, mainly due to both states wanting more land for expansion and increase in agricultural production (Wolters 1999; Higham 2002a; Higham et al. 2011). Alliances with more distant states were more common, since these states were not seen as threats for expansion. Also, these agrarian kingdoms were heavily reliant on agriculture (Bellwood 1992a; Taylor 1992; Wolters 1999; Osborne 2000). Indeed, inadequacies in agricultural production played a significant part in the demise of some of these kingdoms, most notably the Khmer Empire which collapsed due to a combination of ecological and infrastructural breakdown (Taylor 1992; Wolters 1999; Osborne 2000; Higham 2002a; Coe 2003; Higham 2003).

*Island Southeast Asia – The Maritime Kingdoms*

Influential kingdoms from island Southeast Asia developed from small islands where people with superior seafaring skills managed to conquer the seas and navigated effectively to many different islands to secure territories, and also for trade (Cœèdes 1968; Bentley 1986; Christie 1995; Lape 2003). These maritime kingdoms were quite complex, and were organized differently from the agrarian kingdoms of mainland Southeast Asia. While agriculture was also quite developed in island Southeast Asia as evidenced by the terracing of mountains for rice cultivation in the Philippines and Indonesia, maritime trade of locally manufactured crops and material goods was central to the formation of societies (Cœèdes 1968; Christie 1995; Lape 2003). The seas served as a sort of ‘highway’ for the trade and exchange not just of material goods but cultural influences as well (Lape 2002; Lape 2003).

One of the modern differences of island Southeast Asia from mainland Southeast Asia is religion. In mainland Southeast Asia, influences of Buddhism, and Hinduism to a lesser extent, is more evident while Islam is more commonly widespread in island Southeast Asian countries (Wolters 1999; Osborne 2000). Early forms of Hinduism in Southeast Asia were present at around 2000 years ago and Hinduism became the most dominant religion in the region during the 5th – 14th centuries AD (Cœèdes 1968; Casparis and Mabbett 1992). Buddhism in Southeast Asia was dated to around the fourth and sixth centuries CE and gained
popularity after the 14th century AD and still remains the most dominant religion in mainland Southeast Asia (Cœdès 1968; Casparis and Mabbett 1992). Islam arrived in Southeast Asia much later, at around the 13th century AD and became the most dominant religion in island Southeast Asia, replacing the Hindu-Buddhist beliefs in the region (Andaya and Ishii 1992; Casparis and Mabbett 1992). Christianity arrived in Southeast Asia during the European exploration period, but did not spread widely in the region, with only the Philippines having a predominantly Christian population within the region (Andaya and Ishii 1992; Robertson and Blair 1993).

Though hierarchical societies were prevalent in island Southeast Asia, the implementation was rather different from mainland Southeast Asian states. A ‘segmented’ hierarchy was more common in island Southeast Asian states (Appadurai 1986; Bentley 1986), where the leader of smaller, conquered states, while technically subsumed under the more dominant state, were allowed to manage their day-to-day affairs themselves. The military force of these smaller states may be called upon during times of war by the more dominant state. Also, alliances between smaller and larger states were quite complex. Though the leader of the smaller states saw themselves as equal to the leaders of the larger, more dominant states, approval of the more dominant states were usually sought for important political decisions made by the smaller states (Garcia 1979; Christie 1995; Lape 2003). Megalithic structures such as those seen in Cambodia and Thailand were absent in island Southeast Asia, with the exception of Sumatra and Java in Indonesia, where the seat of the dominant maritime empires were located (Harrison 1955; Williams 1976; Wolters 1999; Osborne 2000). Moreover, agriculture, while a significant contributing factor in the economy of island Southeast Asian states, was not the only main source of food. While remains of domesticated rice is commonly found in archaeological sites from mainland Southeast Asia, direct evidence is rare in island Southeast Asia (Higham 1984; Snow et al. 1986; Maloney et al. 1989; Bellwood et al. 1992; Higham 1995; Higham and Lu 1998; Higham 2002b; Bellwood 2005; Higham et al. 2011). Not surprisingly, marine remains were more common in archaeological sites within insular Southeast Asia throughout the prehistoric period, while an increased reliance on rice cultivation was found in the later prehistoric period of mainland Southeast Asia (Higham 1984; Maloney et al. 1989; Bellwood et al. 1992; Higham 1995; Higham and Lu 1998; Krigbaum 2003; Tanaka 2004; Piper et al. 2011). This ensured a more varied subsistence for island Southeast Asians and eliminated the problem of being excessively reliant on one form of resource.
Two great maritime kingdoms that developed extensive networks within island and mainland Southeast Asia as well as China include the Srivijaya Empire and the Madjapahit Empire (Harrison 1955; Williams 1976; Garcia 1979; Wolters 1999; Osborne 2000). The Srivijaya Empire, based in Sumatra, reached its height of power at around 2800 years ago (Harrison 1955; Williams 1976; Osborne 2000). Based on archaeological data, it is hypothesized that the original seat of power of the Srivijaya was in the region of Palembang in southern Sumatra (Bellwood 1985). The Srivijaya Empire controlled ports and waters of the Malacca straits, thereby controlling trade and exchange within the region. However, internal warfare led to the downfall of the empire, with the Madjapahit Empire rising in power afterwards. The rise of the Madjapahit Empire began at around the 13th century (Garcia 1979; Wolters 1999). Situated in Java, the influence of the Madjapahit Empire reached as far north as Luzon in the Philippines during the height of its power (Garcia 1979). During their decline, the Madjapahit still had influence over most of the surrounding areas. Another group which had considerable influence within island Southeast Asia was the Champa. Though they came from Southern Vietnam in mainland Southeast Asia, the Champa were coastal, maritime people and experienced seafarers (Wolters 1999). Their influence extended to as far as Taiwan and the northern Philippines as evidenced by archaeological artifacts of Vietnamese origin (Solheim 2000; Solheim 2006).

The Neolithic and Metal Age in Southeast Asia

Scholars focusing on the early prehistory of Southeast Asia applied terms for Western prehistory to the region such as the ‘Neolithic,’ ‘Iron Age’ and the like. However, some researchers noted that these Western concepts do not exactly fit the Southeast Asian context (Bellwood 1978). Nonetheless, these terms are still being used to describe and compare groups of material culture within a relative temporal perspective. While terms such as the Neolithic describe mainly stone tools made by aborigines and later migrants, other labels such as the Metal Age, Iron Age and Bronze Age describe differences in tool-making and pottery manufacture according to the rise of the great kingdoms within the region (Bellwood 1978; Osborne 2000). The dates for these periods when applied to the Southeast Asian region do not necessarily match the Western definition. Rather, these terms are used to date archaeological artifacts within the region relative to each other. Indeed, the dates for the Neolithic period vary in different areas within Southeast Asia (Bellwood 1978).

The Neolithic period in Southeast Asia is marked by polished stone tools, refined bone tools, cord-marked pottery and the absence of metal (Bellwood 1978; Bellwood 1985; Glover
The Neolithic period is used to describe sites with evidence of agriculture but had no metal artifacts (Oxenham et al. 2011). Due to the abundance of research on the Neolithic in Southeast Asia in recent times, more information has become available, particularly regarding the emergence and spread of agriculture and the transition to the Metal Age (Bellwood 1978; Bellwood 1985; Bellwood et al. 1995; Glover and Bellwood 2004; Bellwood 2005; Higham et al. 2011; Spriggs 2011). The Neolithic is also associated with the spread of the Austronesians to Southeast Asia and the Pacific (Spriggs 2011).

The terms Neolithic and Metal Age are usually applied to sites in mainland Southeast Asia, particularly Thailand, which has a long established temporal sequence of archaeological sites. For other parts of the region, particularly in insular Southeast Asia, the temporal sequences of prehistoric sites are not very well established. Thus, a different temporal division is used which is more suitable for island Southeast Asia. Such is the case of Philippine past, where the commonly taught chronological division of the past is a bipartite one – prehistory and history, which are basically the periods before and after the arrival of Europeans (Agoncillo 1990; Salazar 1991; Salazar 1997). An emic or native perspective of the Philippine past had been argued to be more appropriate in the teaching of Philippine prehistory and history, where temporal divisions were made by Filipino scholars instead of foreign historians (Salazar 1991; Salazar 1997; Salazar 2000; Guillermo 2003). Recent studies on prehistoric archaeology had enabled researchers to further divide Philippine prehistory into three periods: Stone Age, Bronze Age and Iron Age (Cuevas 1992; Dizon 2000; Solheim 2002; Bacus 2004; Szabo et al. 2004). These periods were marked by differences in manufacture and decorations of different artifacts such as pottery and other tools (Dizon 1979b; Dizon 1979c; Dizon 1979a; Cuevas 1992; Dizon 2000; Solheim 2002; Bacus 2004). For example, the Iron Age in the Philippines is marked by more elaborate pottery decorations, and early and late Iron Age were differentiated based on these decorations along with the manufacturing technique of the pottery (Dizon 1979b; Dizon 1979c; Dizon 1979a; Dizon 2000; Solheim 2002).

**Colonial History**

Exploration of Southeast Asia by Europeans began at around the sixteenth century. The main aim of these explorations was to trade for rare spices and textile fabrics, which were very much sought after in Europe, in exchange for European surplus items, which the Southeast Asians saw as items of status and luxury (Williams 1976; Robertson and Blair...
Eventually, colonization of the region ensued after disputes regarding monopolies of these sought-after items and also for the exploitation of resources for financial gain (Osborne 2000; SarDesai 2010). Some European states had agreed to divide the region they were to colonize among themselves. One particularly notable agreement was the treaty of Tordesillas between Portugal and Spain (Robertson and Blair 1993). They had divided the area into Eastern and Western parts, and the Eastern parts were to be colonized by Spain and the Western parts by Portugal (Robertson and Blair 1993). However, the implementation of this agreement was difficult since they had not fully explored the area and the boundaries were thus not clearly defined (Robertson and Blair 1993).

The Philippines and Malacca, one of the sultanates in Malaysia, were among the earliest to be colonized by Europeans. The Philippines was initially colonized by Spain while Malacca was colonized by Portugal during the mid-16th century (Harrison 1955; Williams 1976; Robertson and Blair 1993; Osborne 2000; SarDesai 2010). The Dutch took over Malacca around the mid-17th century and their colonized territories spread to include most of Indonesia (Osborne 2000; SarDesai 2010). During the late 18th to early 19th century, the British first colonized Malaysia and Singapore, and then occupied Burma and the island of Borneo while the French controlled Indochina, which is made up of the present-day Cambodia, Laos and Vietnam (Osborne 2000; SarDesai 2010). It was around this time that the British tried unsuccessfully to take over the Philippines from the Spaniards (Robertson and Blair 1993). The Spaniards made an agreement with the United States to hand over control of the Philippines in exchange for protection from the British forces (Robertson and Blair 1993). This agreement, called the treaty of Paris of 1898, was an arrangement for peace between the two countries on the condition that Spain would cede the Philippines to the United States (Agoncillo 1969; Roces 1977; Agoncillo 1990; Robertson and Blair 1993). This treaty marked the rise of the United States and the decline of Spain as a colonial power in the Southeast Asian region (Robertson and Blair 1993).

The Prehistory and Early History of the Philippines

A summary of the prehistory and early history of the Philippines is essential in understanding the context of the samples from a more detailed perspective. Also, the nature of Philippine prehistory and how it is similar and different from other parts of Southeast Asia offer clues which help in understanding the reasons for the similarities and differences found in the pattern of health and disease of the different skeletal samples from the Southeast Asian region.
The Philippines is an archipelago comprising of 7107 islands and is one of the countries belonging to the region of island Southeast Asia. The country lies to the south of Taiwan, off the southeast coast of China and the eastern coast of Vietnam and is the northernmost among the nations that make up island Southeast Asia. Trade and exchange with neighboring Southeast Asian states and the Chinese during the late prehistory in Southeast Asia had been extensive in many different islands of the Philippines (Garcia 1979; Junker 1993; Junker 1998). This is evidenced by the different trade items found in the archaeological record throughout the Philippines as well as historical documents from neighboring Southeast Asian countries and China (Agoncillo 1969; Junker 1998; Lape 2003). Also, due to its strategic location, the Philippines was colonized by three different nations; namely Spain, the United States of America and Japan. Among all Southeast Asian countries, the Philippines was the most colonized by Western nations.

Prehistory in the Philippines was commonly identified as the period before the arrival of the Spaniards, the first western colonizers of the land. However, the discovery of a pre-colonial document written in a copper sheet dated to around 900 AD has pushed the Philippine prehistoric period to an earlier date (Postma 1991). It can be argued that, prior to the colonization of the Spanish, there was no ‘Philippines’ as the country was very much divided, with most islands separated into chiefdoms of the lowland plains and nomadic tribes of the highlands (Junker 1998). Groups from each region were described to have their own distinct traits and customs (Agoncillo 1969). Each group saw themselves as autonomous to other groups, though sometimes smaller groups made some political decisions which would have favored themselves to stronger groups (Junker 1993; Junker 1998). The regionalism attitude that prevails among Filipinos today is a remnant of that division, where allegiance to one’s ethnic group is stronger than the allegiance to the country. Indeed, as the country’s name suggest, the Philippine islands only became united as a single entity by the Spaniards who named the archipelago after their sovereign, King Philip II (Agoncillo 1969; Robertson and Blair 1993).

**Prehistoric Environment**

Not much is known about the prehistoric environment of the Philippines. What is known is based mostly on archaeological data from different sites all over the archipelago. Only a few of these sites are explored thoroughly (Solheim 1961; Fox 1970; Dizon 2000; Paz and Ronquillo 2004; Bellwood and Dizon 2005; Paz and Ronquillo 2005-2006; Paz and
Ronquillo 2007; Paz et al. 2008; Paz et al. 2009; Paz et al. 2010), thus giving us patchy details on past environment of the archipelago.

The Philippine archipelago is classified as an island arc – groups of islands formed over millions of years from volcanic eruptions situated near the boundaries of two converging tectonic plates (Stern 2010). The archipelago is rife with active volcanoes, and most of these volcanoes are the focus of folk stories regarding local deities. The Philippines belong to the so-called “Pacific Ring of Fire,” a group of islands around the Pacific which are considered earthquake and volcanic eruption hotspots due to the activity of tectonic plates in the region (Stern 2010). Most of the Philippines belong to the Sahul shelf, along with most of the Pacific, while the island of Palawan belongs to the adjacent Sunda shelf, along with mainland Southeast Asia and China (Yumul et al. 2003). It is hypothesized that Palawan was connected to mainland Southeast Asia during the Pleistocene, when sea levels were much lower than they are currently (Yumul et al. 2003). Archaeological finds support this hypothesis, with remains of extinct fauna such as tiger and deer found in earlier layers in Ille Cave, Palawan (Piper et al. 2008; Piper et al. 2011). These animals were also present in mainland Southeast Asia but not in other parts of the Philippines or island Southeast Asia. The abundance of shell middens in both coastal and inland sites within Palawan indicates that marine resources were a major part of prehistoric diet. Also, extensive marine faunal middens in remote caves such as Tabon Cave in central Palawan suggest a different coastline during prehistory (Fox 1970). The shift in faunal middens in inland sites from predominantly deer to pig suggests an extinction of the former as a food source which was replaced with the latter (Piper et al. 2008; Piper et al. 2011).

**Settlement of the Philippines**

It is hypothesized that the initial human settlement of the Philippines was from south to north (Beyer 1947; Zamora 1967; Fox 1970; Garcia 1979). However, as discussed in the previous section, research on the Austronesian migration suggests that there was a north-to-south settlement of the region, including the Philippines (Bellwood et al. 1995; Glover and Bellwood 2004). Initial settlers of the Philippines were believed to be of the ‘Negrito’ type, and descendants of these people can still be found in the islands today mainly in the highlands (Zamora 1967; Garcia 1979). Another migration of a different group of people, the Austronesians, occurred at around 5000 years ago and it was the descendants of these people who make up the majority of the current population in the Philippines (Bellwood et al. 1995). Expansion of the population is caused by the intensification of agriculture, and lead to the
development of complex societies (Bellwood et al. 1995; Higham 2002a; Bellwood 2004; Glover and Bellwood 2004). It was during the rise of these complex societies that trade and exchange became extensive, which lead to the spread of Chinese and Indian influences within the archipelago. The island of Sulu in particular became one of the main trade centers in Southeast Asia, with sailors from Cambodia, Champa (Southern Vietnam), China, Sumatra, Java, India and Arabia arriving on Sulu’s shores for trading purposes (Garcia 1979).

**Relations with other Southeast Asian States before the arrival of Europeans**

Though not very prominent among the nation-states of Southeast Asia, Philippine chiefdoms had extensive alliances not just with neighboring states but also with empires from further shores, including the Chinese (Hutterer 1977; Garcia 1979; Junker 1993; Junker 1998). Vassals were dispatched with numerous luxury items at least once a year from major Philippine chiefdoms to negotiate alliances with China and also to request aid and protection from enemy states (Junker 1993; Junker 1998). Intermarriages among neighboring states were commonly used to form alliance between states (Junker 1993; Junker 1998).

While the Indian influences are not as visible in Philippine culture compared to other Southeast Asian cultures, evidence of the “Indianization” of the Philippines in the past can be seen from the archaeological artifacts discovered in the region. Some examples include the ‘Agusan Image’ found in Agusan Valley in Mindanao; the Calatagan pot found in central Luzon which had carvings of the Alibata script; the Laguna Copperplate Inscription; and the recently discovered Rizal stone in Masbate which also had carvings of the Alibata script. The Alibata or Baybayin as it is otherwise known, an indigenous Philippine form of writing derived from Sanskrit, is also confirmation of the Indian influence within the archipelago (Postma 1991; De Leon 1992). The Laguna Copperplate Inscription, the earliest written document in Philippine history, is a thin sheet of copper with writings in Kawi script detailing the release of a slave from being indebted (Postma 1991). Since the last sentence of the inscription was unfinished, it is supposed that there is another copper piece with the continuation of the message, though this is yet to be found (Postma 1991). The writing on the inscription, the Kawi script, a writing system from Java with Indian origins which is believed to be a common language spoken in the island Southeast Asian region (Postma 1991). The Agusan Image, a 4-pound golden statue which resembles Tara, a Hindu-Malayan goddess, is dated to around the 13th to 14 century, during the early Madjapahit period (Francisco 1963). Francisco (1963) argued that the image is that of a Mahayana Buddhist figure but other scholars suggest that the image is of Hindu origin. This image is an indication of the
abundance of gold in the area reported by ethnohistoric accounts where gold exchange with neighboring states was common (Francisco 1963).

Buddhism was, and still is, mainly practiced by Chinese immigrants, with Buddhist temples commonly found in Chinatowns within metropolitan areas around the country (Zamora 1967). The Christian influence of the Spaniards remains prevalent today, with the majority of the population having Catholicism as their religion. However, most of the population in southern Philippines retained Islam as their religion. Islam arrived in the Philippines before the arrival of the Europeans, possibly originating from southern India (Garcia 1979). It has spread throughout most of the country, even in the northern island. The leaders of prominent chiefdoms in Manila practiced Islam before being converted to Catholicism by the Spaniards (Garcia 1979). A significant part of the population in the capital still practices Islam, and there are several mosques that can be found within the metropolitan. During recent times, however, Muslims are more commonly found in the southern island of Mindanao. This can be attributed to the nature of the people living in the different islands during the arrival of the Europeans.

During the rise of the Srivijaya Empire in Sumatra at around 800 to 900 AD, the island of Sulu in southern Philippines served as a trade center with traders from Cambodia, Champa, China, Sumatra, Java, India and Arabia stopping by the island to exchange goods (Garcia 1979). It was also hypothesized that Sulu was a former Champa colony, with Orang Dampuan or foreign settlers arriving at around 900 to 1200 AD (Garcia 1979).

**European Contact Period**

It is commonly known that the European Contact Period began with the arrival of Ferdinand Magellan and his fleet in Homonhon, Samar on March 16, 1521 (Agoncillo 1969; Robertson and Blair 1993). According to historical sources, they were received with warm hospitality by the locals, which was very different from their encounters with other natives from neighboring islands (Robertson and Blair 1993). The Spaniards eventually gained control of most of the islands after a few years, except for certain parts of Mindanao and the highlands of northern Luzon where tribal groups were more hostile to foreigners (Agoncillo 1969; Agoncillo 1990; Robertson and Blair 1993). It was mainly the lowland people of Luzon and Visayas who were more receptive of the idea of a foreign religion, albeit infused with local animistic ideologies, and were thus conquered more easily by the Spaniards (Agoncillo 1990; Robertson and Blair 1993).
Despite having colonized the Philippines for a long time, few Spaniards settled in the islands unlike Spain’s other colonies such as areas in South America (Agoncillo 1990; Robertson and Blair 1993). Spanish was not taught to Filipinos unlike in other colonies, though names of places and people that were baptized into Christianity had their indigenous names changed to Spanish names (Zamora 1967; Agoncillo 1990). According to historical sources, the propagation of Christianity was the main aim of Spain in conquering the Philippines as the region was not very rich in spices that were very much sought after during that period (Agoncillo 1969; Robertson and Blair 1993). As the Spaniards gained more control of the people in the islands, the propagation of Christianity and the construction of elaborate churches began (Agoncillo 1990; Robertson and Blair 1993). Most of the churches built during the Spanish period still stand today, though few have been restored after suffering extensive damage during the Second World War. These churches are usually found in the center of towns planned by the Spaniards and are usually opposite the plaza where influential members of society gather before and after the church services (Agoncillo 1969; Agoncillo 1990; Robertson and Blair 1993). The first towns built by the Spaniards usually have churches at the center with the houses of influential people such as the town governor and priests surrounding the church (Agoncillo 1969; Agoncillo 1990). Less influential people lived further from the center and poor people lived on the periphery of these towns (Agoncillo 1969; Agoncillo 1990). Some of these towns, particularly the larger ones, were fortified to prevent attacks from guerrillas and other invaders (Agoncillo 1990; Robertson and Blair 1993). A good example of this fortified town structure is the Intramuros in Manila. The churches within the walls of Intramuros, the San Agustin church and the Manila cathedral can still be seen today and most of the stone wall bordering the town is still intact.

To organize their new colony, the Spaniards implemented the encomienda system on the areas of the archipelago that they have successfully conquered (Agoncillo 1969; Roces 1977; Agoncillo 1990; Robertson and Blair 1993). The encomienda, which means ‘to entrust,’ is a system where an encomendero or trustee is given a certain region to supervise the natives in education and Catholicism (Agoncillo 1969; Roces 1977; Agoncillo 1990). Though the encomendero has no political authority over the region entrusted to him, his influence over the region has frequently led to exploitation of the natives (Agoncillo 1969; Roces 1977; Agoncillo 1990). The encomendero and the prayle or priest assigned to a particular region were considered the most influential people of that particular town, and these people frequently took advantage of their influence over the people for special favors and preferential treatment (Agoncillo 1969; Roces 1977; Agoncillo 1990). Under the encomienda
system, a policy where natives were forced to serve labor to community projects such as the construction of churches and forts was implemented (Agoncillo 1969; Roces 1977; Agoncillo 1990). This policy, the polo y servicios, was applicable to men age 16 to 60 years of age (Agoncillo 1969; Roces 1977; Agoncillo 1990). These men were forced to serve for at least 40 days and may be exempted upon payment of a fine called the falla, which is a corruption of the Spanish word falta meaning absence (Agoncillo 1969; Roces 1977; Agoncillo 1990).

Bioarchaeology in Southeast Asia

A review of the state of bioarchaeology in Southeast Asia is necessary to provide a background on the study of skeletal remains within this region. Several studies have been done on different aspects of bioarchaeology among Southeast Asian samples, though most of these studies are limited to samples from mainland Southeast Asia, particularly Thailand. Studies on human remains from island Southeast Asia are relatively rare, and as noted most are focused on the paleoanthropological research within the region.

Bioarchaeology is the study of human remains in an archaeological context (Larsen 1997; Buikstra and Beck 2006). The term was previously used to refer to the study of all faunal remains found in an archaeological setting; however it is increasingly used today to refer solely to human remains (Larsen 1997; Larsen 2000; Buikstra and Beck 2006; Agarwal and Glencross 2011). The interpretation and reconstruction of human history and past lifestyles using skeletal remains involves the use of multidisciplinary methods. Since the human experience comprises of the interactions between biology, culture and the environment, these factors need to be taken into account when interpreting behavior and history from human remains. The study of bioarchaeology also includes inherent biases in sampling and restrictions on interpretation since only the skeletal remains are available for analysis (Waldron 1994; Jurmain 1999; Waldron 2001; Waldron 2007). These biases and restrictions need to be taken into consideration so as not to overstretch what could be interpreted from these remains. Issues of ethnicity and biological heritage also need to be addressed when interpreting population history from skeletal remains since ethnicity is a social construct and is not necessarily synonymous to biological heritage (Jackson 1992; Taylor 1997; Gravlee 2009).

There are numerous specialties that fall under the realm of bioarchaeology. These include mortuary rituals and behavior, paleodemography, osteometry, paleoepidemiology, and paleopathology (Larsen 1997; Larsen 2000; Buikstra and Beck 2006; Tayles and Willis 2009;
General questions about the human past such as morphological diversity, quality of life, behavior and lifestyle, and population history are common areas of bioarchaeological inquiry (Larsen 1997; Larsen 2000; Buikstra and Beck 2006; Agarwal and Glencross 2011). As the skeletal remains used in bioarchaeological studies come from archaeological sites, archaeological context is crucial in the interpretation of past behavior and life history. Therefore the archaeological data, along with the skeletal remains, are important for a more holistic understanding of the past. Studies on human remains are generally population based, thus a small skeletal sample will yield a very limited interpretation as it is difficult to interpret the complexity of human history using small samples which do not accurately represent the past population. Since this study focuses on the paleopathology of human remains from Southeast Asia, this section will concentrate on paleopathological studies within the region.

The definition of health used by bioarchaeologists is rather different from the clinical definition. In bioarchaeological studies, health is assessed by the examination of skeletal pathology and the inference of the aetiologies of observed pathologies and its prevalence in the population (Steinbock 1976; Rothschild and Martin 1993; Auferheide and Rodriguez-Martin 1998; Jurmain 1999; Larsen 2000; Ortner 2003; Waldron 2009). In order to provide a holistic picture of prehistoric health, the bioarchaeologist relies on multiple lines of evidence such as archaeological and ethnohistoric data to supplement findings based on skeletal remains.

Studies on bioarchaeology in Southeast Asia have greatly improved in both number and quality in recent years due to the excavations done on prehistoric sites within the region. Though most studies have focused on mainland Southeast Asia, the amount of knowledge gathered from sites with a long period of usage is undeniably very useful in studying the prehistoric past of the region. Archaeological sites particularly in Thailand cover several transitional phases of different periods within prehistory (Higham 1975; Higham and Kijngam 1984b; Tayles 1999; Domett 2001; Pietrusewsky and Toomay 2002; Cameron et al. 2004; Boyd et al. 2007; Boyd et al. 2009). With the large number of samples available from these sites, it is feasible to reconstruct the health and lifestyle of the people who lived during these times. In island Southeast Asia, studies on skeletal remains are mainly concentrated on the origins of island Southeast Asians, focusing on early human and hominin remains (Fox 1970; Dizon et al. 2002; Krigbaum 2003; Detroit et al. 2004; Majid 2005b; Lewis et al. 2008; Higham et al. 2009; Mijares et al. 2010; Barker et al. 2011). However, since more human remains have been recovered from prehistoric and early historic archaeological sites in island
Southeast Asia during recent times, it is essential to start reviewing the current approaches regarding the prehistory and history of the people from this region.

Studies on Southeast Asian bioarchaeology have focused on population history, migration, evolution, health and disease and to a lesser extent morphological diversity and osteometry. Bioarchaeological studies in Southeast Asia have always focused on dentition as an indicator of health and disease and the quality of life during prehistoric times (Tayles et al. 2000; Medrana 2002; Matsumura and Hudson 2005; Halcrow and Tayles 2008). The origins of Southeast Asians remain a popular topic of research among Southeast Asian bioarchaeologists and research on this subject is usually done in collaboration with archaeologists focusing on Austronesian origins. Studies on mortuary behavior and rituals are usually carried out by archaeologists and mostly focus on artifacts found with the human remains and rarely discuss the method of burial, though a recent study by Tayles and Willis (2009) has focused on this aspect of bioarchaeology.

As reviewed above, more research on the differences in the prehistory of humans in island and mainland Southeast Asia is needed. Archaeological artifacts and ethnohistorical accounts tell us that there is a difference in the way of living in these two areas due to the differences in the landscape, climate patterns and political organization within the region. Archaeological studies within island Southeast Asia have advanced over the years with the excavation of numerous prehistoric and early historic sites. However, analyses on these sites were focused mainly on the artifacts, botanical and zoological remains recovered with the human remains and not on the human remains themselves. This can be attributed to the poor preservation of the skeletal remains but also due to the lack of specialist training in the analysis of skeletal remains as part of the interpretation of archaeological data. The excavation of human remains is also rather restricted due to the lack of storage for the skeletal materials which leads to fewer samples for study. In Malaysia, several studies on skeletal morphology, paleopathology and oral health of prehistoric remains have been accomplished (Majid 2005b). Apart from the skeletal remains from Niah Cave (Krigbaum and Datan 2005; Krigbaum and Manser 2005; Majid et al. 2005b; Majid and Pfister 2005), samples were very small in size and detailed analyses of these few remains have been carried out (Bulbeck 2005a; Bulbeck 2005b; Bulbeck and Taha 2005; Chia and Hassan 2005; Jacob and Soepriyo 2005; Majid 2005a; Majid et al. 2005a; Matsumura and Majid 2005; Sai 2005; Samsuddin and Nizam 2005). The majority of the bioarchaeological studies of skeletal samples from Malaysia were concentrated on osteometrics, biodistance and population origins (Bulbeck 2005a; Bulbeck 2005b; Bulbeck and Taha 2005; Chia and Hassan 2005; Jacob and Soepriyo
In the Philippines, studies of human remains were usually done by foreign specialists due to the lack of professionally trained experts in the country (Zamora 1967). These studies focused more on osteometry, identification of racial origins and paleopathology of a number of samples without an interpretation of their findings within the context of Philippine or Southeast Asian prehistory (Zamora 1967). Current studies have included sections on the human remains from archaeological sites (Medrana 2000; Medrana 2002; Lewis et al. 2008), though samples were limited and the focus is mainly on early prehistoric remains which are few and poorly preserved. Thus, interpretations gathered from such small samples are rather restricted. Descriptive reports on human burials from archaeological sites (Solheim 1954; Solheim 1961; Dizon 1979b; Dizon 1979c; Dizon 1979a; Cuevas 2003; Paz and Ronquillo 2004; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009; Paz et al. 2010) are more common than specialized studies on paleopathology and prehistoric health.

Bioarchaeological Studies in Southeast Asia

Several archaeological sites in Southeast Asia, mainly from the mainland, have yielded numerous human burials spanning different time periods from the Neolithic to the Metal Age. A short synopsis on these sites is presented to provide a background on the research done within the region. The sites are reviewed in geographic and chronological order.

A summary of the bioarchaeological sites within Southeast Asia and the time periods of these sites are shown in Table 2.1.
Table 2.1. Bioarchaeological sites in Southeast Asia and the dates of the burials.

<table>
<thead>
<tr>
<th>Site</th>
<th>Region</th>
<th>Dates</th>
<th>Time Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khok Phanom Di</td>
<td>SE Thailand</td>
<td>2000 - 1500 BC</td>
<td>Neolithic</td>
</tr>
<tr>
<td>Nong Nor</td>
<td>SE Thailand</td>
<td>1100 - 700 BC</td>
<td>Bronze Age</td>
</tr>
<tr>
<td>Ban Chiang</td>
<td>NE Thailand</td>
<td>2100 BC - 200 AD</td>
<td>Neolithic to early Iron Age</td>
</tr>
<tr>
<td>Non Nok Tha</td>
<td>NE Thailand</td>
<td>2000 - 1000 BC</td>
<td>Neolithic to Bronze Age</td>
</tr>
<tr>
<td>Ban Non Wat</td>
<td>NE Thailand</td>
<td>1750 BC - 500 AD</td>
<td>pre-Neolithic to Iron Age</td>
</tr>
<tr>
<td>Ban Lum Khao</td>
<td>NE Thailand</td>
<td>1300 - 500 BC</td>
<td>Neolithic to Bronze Age</td>
</tr>
<tr>
<td>Ban Na Di</td>
<td>NE Thailand</td>
<td>600 - 400 BC</td>
<td>late Bronze Age to Iron Age</td>
</tr>
<tr>
<td>Noen-U-Loke</td>
<td>NE Thailand</td>
<td>400 BC - 300 AD</td>
<td>Iron Age</td>
</tr>
<tr>
<td>Con Co Ngua</td>
<td>northern Vietnam</td>
<td>5500 - 6000 BP</td>
<td>Neolithic</td>
</tr>
<tr>
<td>Man Bac</td>
<td>northern Vietnam</td>
<td>3500 - 3800 BP</td>
<td>Neolithic</td>
</tr>
<tr>
<td>Ma, Ca Rivers</td>
<td>northern Vietnam</td>
<td>2500 - 1700 BP</td>
<td>Metal Period</td>
</tr>
<tr>
<td>Red River</td>
<td>northern Vietnam</td>
<td>2200 - 1700 BP</td>
<td>Metal Period</td>
</tr>
<tr>
<td>Gua Gunung Runtu</td>
<td>peninsular Malaysia</td>
<td>10120 ± 110 BP</td>
<td>Paleolithic</td>
</tr>
<tr>
<td>Gua Cha</td>
<td>peninsular Malaysia</td>
<td>10000 - 1000 BP</td>
<td>Hoabinhian to Neolithic</td>
</tr>
<tr>
<td>Gua Teluk Kelawar</td>
<td>peninsular Malaysia</td>
<td>8400 ± 40 BP</td>
<td>Neolithic</td>
</tr>
<tr>
<td>Gua Peraling</td>
<td>peninsular Malaysia</td>
<td>6000 – 8000 BP</td>
<td>Neolithic</td>
</tr>
<tr>
<td>Guar Kepah</td>
<td>peninsular Malaysia</td>
<td>4000 – 5000 BP</td>
<td>mid-Holocene</td>
</tr>
<tr>
<td>Gua Harimau</td>
<td>peninsular Malaysia</td>
<td>1135 BC – 1160 AD</td>
<td>Neolithic to Metal period</td>
</tr>
<tr>
<td>Niah Cave</td>
<td>Malaysian Borneo</td>
<td>21000 - 2000 BP</td>
<td>upper Pleistocene to Neolithic</td>
</tr>
<tr>
<td>Shi San Hang</td>
<td>northern Taiwan</td>
<td>1800 - 500 BP</td>
<td>Iron Age</td>
</tr>
</tbody>
</table>

Sites from Thailand

This section provides a background on the archaeological sites in Thailand from which bioarchaeological studies have been conducted. A summary of the results of these bioarchaeological studies is presented in the following section.
Southeast Thailand

Khok Phanom Di

Khok Phanom Di is a coastal site in southeast Thailand where archaeological excavations have uncovered an occupation site dated to around 2000-1500 BC (Higham and Thosarat 1990; Tayles 1999). The artifacts, botanical and zoological remains as well as burials recovered from this area demonstrated the transition of settlers from a hunting-gathering lifestyle to agriculture (Higham and Thosarat 1990; Higham et al. 1993; Thompson 1996). Three major occupations had been inferred from archaeological data that corresponds with the regression of sea level and transition to rice cultivation (Higham and Thosarat 1990). During the first occupation, the site was inferred to be near a major estuary with easy access to marine, mangrove, riverine and freshwater sources (Higham and Thosarat 1990).
Archaeological evidence indicated a reliance on fishing and gathering of crops during this occupation (Higham and Thosarat 1990; Higham et al. 1993; Thompson 1996). The regression of sea level led to the loss of access to marine and freshwater sources and the reliance on rice agriculture during the middle period of occupation (Higham and Thosarat 1990; Thompson 1996). A resurgence in the presence of marine and the cease of rice cultivation marked the final phase of occupation in the site (Higham and Thosarat 1990; Thompson 1996). A total of 154 individuals were recovered from the site, 86 of whom were subadults and 68 of whom were adults (Tayles 1999). Among the adults, 36 were assessed as females and 32 as males (Tayles 1999).

**Nong Nor**

Nong Nor is located approximately 14 km south of Khok Phanom Di in the lower Bang Pakong River Valley (Boyd et al. 1998; Domett 2001). Evidence of prehistoric occupation was found and dated to around 2450 BC which preceded the occupation at Khok Phanom Di (O'Reilly 1998; Domett 2001). The second phase of the occupation at Nong Nor is marked by the presence of a cemetery dated to the Bronze Age (Higham and Thosarat 1998; Domett 2001). The archaeological record of the site indicated that the people who lived there had access to aquatic resources (Mason 1998; Domett 2001). Remains of animals such as the domestic dog, pig, cattle and chickens were also found from the site (Higham et al. 1998). The artifacts recovered from the site suggested that the people from Nong Nor made their own pottery using local resources (Boyd et al. 1998; Domett 2001). No evidence of metal production was found, though evidence of shell jewelry manufacturing was observed from the site (Boyd et al. 1998; Domett 2001). Evidence of rice agriculture, hunting and fishing in addition to the domestication of animals for food was also found (Boyd et al. 1998). A total of 168 burials were recovered from the site, though 15 burials did not contain any human bones (Tayles et al. 1998; Domett 2001). From these burials, 155 individuals were identified, 33 of whom were subadults and 122 of whom were adults (Tayles et al. 1998). Among the adults, 49 were identified as females, 44 as males and 29 were of unknown sex (Tayles et al. 1998). The preservation of the remains was rather poor due to natural and human-induced taphonomic processes on the site (Tayles et al. 1998).
Northeast Thailand

Ban Chiang

Ban Chiang is located at the northeastern region of Thailand (Pietrusewsky and Toomay 2002). This archaeological site is similar to Non Nok Tha which is also located in the same region; both sites have a long sequence of occupation which illustrates the transition of lifestyle from hunting and gathering to the adoption of agriculture (Bayard 1971; Higham 1975; Pietrusewsky and Toomay 2002). A change in environment during the middle phase of occupation suggesting the loss of woodlands and a gain in grasslands was observed from archaeological evidence on the site (Pietrusewsky and Toomay 2002). Wet rice agriculture in the area was established at around 2300-1800 BP (Pietrusewsky and Toomay 2002). A total of 142 individuals from the Ban Chiang and the Ban Chiang Eastern Soi excavation sites were identified, 45 of whom were subadults and 97 as adults (Pietrusewsky and Toomay 2002). Among these, 65 were classified as males, 60 as females, and 17 were of unknown sex (Pietrusewsky and Toomay 2002).

Non Nok Tha

Non Nok Tha is another site in northeast Thailand with an occupation that covers the transition from foraging to agriculture (Douglas 2006). The site was dated to around 5000-2500 BP and three major periods of occupation were observed (Bayard 1971; Higham 1975; Douglas 2006). It is situated to the south of Ban Chiang, another archaeological site with a long occupation period, and at the junction of two streams (Bayard 1971; Higham 1975; Douglas 2006). Archaeological evidence suggested a change in lifestyle of the settlers from hunting and gathering to the cultivation of wild rice (Bayard 1971; Higham 1975; Douglas 2006). Evidence of aquatic resources as well as domestication of pigs and cattle was also found in the site (Bayard 1971; Higham 1975). The first period of occupation was from the pre-metal period where hunting and gathering was supplemented by some cultivation and was dated to be from as early as 5000 BP to around 4000 BP (Bayard 1971; Pietrusewsky 1974; Higham 1975; Douglas 2006). Domestication of animals and more intensive plant cultivation started at around 4100-2900 BP while the later period was marked with the presence of iron, low intensity burning of forests and remains of water buffalo suggesting a higher reliance in agriculture (Bayard 1971; Pietrusewsky 1974; Higham 1975; Douglas 2006). A total of 83 individuals have been recovered from the site, 64 of whom were adults and 19 of whom are subadults (Pietrusewsky 1974). Among the adults, 25 were classified as males, 33 as females, and 6 were of unknown sex (Pietrusewsky 1974).
**Ban Non Wat**

Ban Non Wat is a site in northeast Thailand close to the Mun River (Boyd et al. 2009). Evidence of occupation from the Neolithic to the Iron Age was recovered from the site (Boyd et al. 2009). Neolithic occupation in the Mun valley was observed from only two other sites: Ban Lum Khao and Ban Tamyae (Cameron et al. 2004; Boyd et al. 2009). The Neolithic occupation in Ban Non Wat was marked by rice cultivation, animal domestication, evidence of fishing and shellfish gathering as well as hunting for wild game (Boyd et al. 2009). The early Neolithic period in the site was dated to around the late 16th and 15th centuries BC, while the later Neolithic was dated to around 12th to 11th century BC (Boyd et al. 2009). The late Neolithic was marked by the presence of different ceramics which closely paralleled those found at Ban Lum Khao (Boyd et al. 2009). The Bronze Age was marked by more elaborate burials such as the presence of shell beads and bangles as well as pig bones in most burials (Higham 2009). As the Bronze Age progressed, burials became more elaborate, and individuals were often buried with exotic goods such as glass, gold, carnelian and agate (Higham 2009). However, a decline in elaborate grave goods and shell adornments in later Bronze Age and Iron Age burials was observed (Higham 2009).

**Ban Lum Khao**

Ban Lum Khao is a metal age site in northeast Thailand with evidence of intensive irrigated wet rice agriculture (Cameron et al. 2004). Initial occupation dates to around the late Neolithic and evidence of marine resources such as shellfish, fish and turtles as well as mammalian remains such as water buffalos, deer, pigs and dogs were found during the initial occupation of the site (Cameron et al. 2004). Evidence of these varied sources of subsistence continued into the late Bronze period except for the water buffalo (Cameron et al. 2004). This implied a varied food source combined with rice and other plants. Three mortuary phases were observed from the site (Higham and Thosarat 2004a; Higham and Thosarat 2004b; Higham and Thosarat 2004c). Associated ceramics from the first mortuary phase suggested that this period dates from the Neolithic at around 1300-1000 BC (Higham and Thosarat 2004a). Burials from the second mortuary phase fall under the Bronze Age period and contained the majority of the burials (Higham and Thosarat 2004b). The third mortuary phase constituted the burials from the latest stages of the Bronze Age and associated pottery from this phase showed close similarities to the late Bronze Age ceramics from the Ban Non Wat burials (Higham and Thosarat 2004c). A total of 110 burials were recovered from the site which represented 110 individuals (Domett 2004). From these individuals, 51 were subadults.
and 59 were adults. Among the adults, 32 were females and 27 were males (Domett 2004). The relatively good preservation of the individuals from Ban Lum Khao enabled fairly reliable estimates of sex for all individuals (Domett 2004).

*Ban Na Di*

Ban Na Di is situated to the north of Ban Chiang on the upper Songkhram area of the Khorat Plateau (Higham and Kijngam 1984b). The burials excavated at Ban Na Di were dated to the late Bronze Age to the Iron Age thus spanning the transition between two different time periods (Higham and Kijngam 1984a; Domett 2001). The burials were dated to be from around 900 – 100 BC (Higham and Kijngam 1984a). Remains of domesticated animals as well as aquatic animals indicated that the inhabitants of Ban Na Di had a diverse diet (Higham and Kijngam 1984b). However, shellfish remains were seen only until the layer dated to around 1500 – 900 BC (Higham and Kijngam 1984b). This indicated a possible change in the environment during this period. The site is located near three small streams which would have provided a fresh water resource for the settlers (Higham and Kijngam 1984b). Evidence of rice agriculture was found on the site (Higham and Kijngam 1984b). Later occupations of the site provided evidence of metal manufacturing (Higham and Kijngam 1984b). A total of 74 individuals were used in the study by Houghton and Wiriyaromp (1984), while 78 individuals were used in a more recent study by Domett (2001) which included five fetal skeletons. Domett’s research is used as a reference in this study since it is an updated version of Houghton and Wiriyaromp’s analysis on the Ban Na Di remains. Among those used in the study, 28 were identified as subadults and 50 were adults (Domett 2001). In adults, 20 were assessed as females, 25 as males and 5 were of unknown sex (Domett 2001).

*Noen-U-Loke*

Noen-U-Loke is a burial mound site in the Huai Yai valley in northeast Thailand (Cameron et al. 2004; Boyd et al. 2007). Archaeological evidence indicated the presence of hierarchical and centralized societies in the site with widening exchange networks (Boyd et al. 2007). Iron working assisted in the further intensification of rice agriculture and rice became an abundant staple and was even used as backfill for burials (Boyd et al. 2007). Evidence of other forms of subsistence such as pig, cattle, water buffalo, fish and other plants were also found (Boyd et al. 2007). Five mortuary phases were observed from this site, all of which were dated to the Iron Age (Higham and Thosarat 2007h; Higham and Thosarat 2007g; Higham and Thosarat 2007a; Higham and Thosarat 2007b; Higham and Thosarat 2007c;
Higham and Thosarat 2007d; Higham and Thosarat 2007e; Higham and Thosarat 2007i; Higham and Thosarat 2007f). The first mortuary phase was represented by a single burial with associated pottery which might have belonged to the late Bronze Age (Higham and Thosarat 2007h). Six burials belonged to the second mortuary phase, and a stray maxilla in a pit was found to be from the same phase (Higham and Thosarat 2007h). Several artifacts such as pottery, animal bones fashioned into accessories and metal jewelry were found along with the burials (Higham and Thosarat 2007h). The third mortuary phase was divided into two clusters while the fourth mortuary phase was divided into four clusters (Higham and Thosarat 2007g; Higham and Thosarat 2007a; Higham and Thosarat 2007b; Higham and Thosarat 2007c; Higham and Thosarat 2007d; Higham and Thosarat 2007e; Higham and Thosarat 2007i). These burials were divided into different phases and clusters based on the location of the burials relative to each other and the stratigraphic sequence of the burials (Higham and Thosarat 2007h). A total of 88 burials were recovered from the site, and within these burials 120 individuals were found (Tayles et al. 2007). The subadults comprised 53 of the total individuals and 67 were adults (Tayles et al. 2007). Among the adults, 21 were classified as females, 27 were males and 19 were of unknown sex (Tayles et al. 2007). The adult sample consisted of 24 young adults, 14 mid-adults, 12 old adults and 13 adults of unknown age (Tayles et al. 2007).

Sites from Vietnam

This section presents a synopsis of the archaeological sites in Vietnam where bioarchaeological studies have been carried out.
Con Co Ngua

Con Co Ngua is a Neolithic cemetery site belonging to the Da But period of Vietnam (Oxenham et al. 2002). The site is located in northern Vietnam, to the north of the Ma River in Ha Trung district, Thanh Hoa province (Oxenham et al. 2002; Oxenham et al. 2006). Con Co Ngua is approximately 30km from the current coast and the population consisted mainly of sedentary foragers (Oxenham et al. 2002; Oxenham et al. 2006). A range of faunal remains such as buffalo, pig, turtle, fish, oyster, mussels and snails were found on the site suggesting a varied diet (Oxenham et al. 2002; Oxenham et al. 2006). The site is dated to the post-Hoabinhian period of around 5500 to 6000 years BP (Oxenham et al. 2002; Oxenham et al. 2006). A total of 81 individuals were recovered from this cemetery site (Oxenham et al. 2002).
Man Bac

Man Bac is a Neolithic site in northern Vietnam dated to around 3500-3800 BP (Oxenham et al. 2011). The site is approximately 25km from the coast and is surrounded by karst limestone mountains (Oxenham et al. 2011). Man Bac is situated in the lowland plain of Bac Bo (Oxenham et al. 2011). The individuals used in bioarchaeological studies from this site were from the burials recovered during the excavation seasons from 1999 – 2005 (Oxenham et al. 2011). A total of 84 individuals were recorded from the site, though six of the burials were not assessed since these burials were either not excavated or were represented by very minimal remains (Oxenham et al. 2011). Previous studies on the human remains from Man Bac had revealed an age-based social hierarchy, a palliative care system, and the expression of social identity through funerary practices (Oxenham et al. 2008a; Oxenham et al. 2008b; Oxenham et al. 2009; Oxenham et al. 2011).

Ma, Ca and Red Rivers

Eleven assemblages from several sites near the Ma, Ca and Red Rivers were used to represent the Metal or Dong Son period in Vietnam (Oxenham et al. 2002; Oxenham et al. 2006). These individuals were separated into two samples for analysis (Oxenham et al. 2002; Oxenham et al. 2006). The first sample consisted of 23 individuals excavated from sites near the Red River delta and dated to around 2200 to 1700 BP (Oxenham et al. 2002; Oxenham et al. 2006). Forty-five individuals mainly from the Ma River sites were used in the other sample dated to around 2500 to 1700 years BP (Oxenham et al. 2002; Oxenham et al. 2006). Evidence of craft specialization, complex rituals, development of a social hierarchical system, maritime trade, and sophisticated military skills and equipment were found on the sites (Oxenham et al. 2002; Oxenham et al. 2006). The Dong Son period was described by Higham (1989a, p.30) as an example of the transition “from village autonomy towards centralized chiefdoms.”
Sites from Malaysia

Archaeological sites from Malaysia which yielded human remains are discussed in this section.

Figure 2.4. A map of Malaysia featuring the archaeological sites mentioned in this study. Map adapted from Majid (2005b).

Peninsular Malaysia

Gua Gunung Runtuh

Gua Gunung Runtuh is a cave site known as the site where the oldest and most complete skeleton of anatomically modern human from Malaysia was found (Majid 2005a; Saidin 2005). The site is located in the Lenggong Valley in northern Peninsular Malaysia (Majid 2005a; Saidin 2005). Human occupation at the site dates back to around 74000 years ago and the Perak Man, the only skeletal remains found in the cave, was radiocarbon-dated to 10120 ± 110 BP (Majid 2005a). Based on the archaeological evidence found on the site, the cave was mainly used for habitation and mortuary artifacts suggested the presence of a Paleolithic tradition associated with the Perak Man (Majid 2005a).

Gua Cha

Gua Cha, a rockshelter site in the central uplands of peninsular Malaysia, has also yielded burials from around the same time frame as Niah (Bulbeck 2005a; Barker et al. 2011). Evidence of Hoabinhian occupation was found at Gua Cha which was dated to around 10000-3000 BP and the burials found from this period were primarily flexed (Bulbeck 2005a; Barker et al. 2011). Archaeological data also suggested that the site was used as a cemetery during the Neolithic period dating from 3000-1000 BP (Bulbeck 2005a). Archaeological evidence of
a cultural connection to Ban Kao in southern Thailand was found, as well as evidence of increased sedentism and dependence on forest resources (Bulbeck 2005a; Barker et al. 2007; Barker et al. 2011). The Neolithic period in Niah and Gua Cha was marked with the consumption of plant foods grown in open plots but evidence of rice was absent from archaeological contexts (Bulbeck 2005a).

Gua Teluk Kelawar

Another rockshelter site in northern Peninsular Malaysia is Gua Teluk Kelawar where a skeleton dated to 8400 ± 40 BP was found (Majid et al. 2005a). The site is within the vicinity of Gua Gunung Runtuh and evidence of occupation was dated to as early as 10245 ± 80 BP (Majid et al. 2005a).

Gua Peraling

Gua Peraling is another rockshelter site near Gua Cha where few skeletal remains were found (Bulbeck and Taha 2005). The rockshelter is located near the village of Tohoi in the district of Ulu Kelantan (Bulbeck and Taha 2005). Radiocarbon dating of charcoal associated with three burials from the site yielded dates of around 6000 to 8000 years ago (Bulbeck and Taha 2005).

Guar Kepah

Guar Kepah is a coastal site located on the western part of peninsular Malaysia (Bulbeck 2005b). The site is approximately 7 kilometers inland and evidence of Hoabinhian assemblages on this site was found (Bulbeck 2005b). Guar Kepah is dated to the middle Holocene, at around 4000 to 5000 years ago based on the archaeological data from the site (Bulbeck 2005b).

Gua Harimau

Gua Harimau (Tiger Cave) is a cave site located near Gua Teluk Kelawar and Gua Gunung Runtuh in peninsular Malaysia (Chia and Hassan 2005). Several burials dated to the late Neolithic and early Metal periods were found from the site (Chia and Hassan 2005). Burials and associated artifacts from the Neolithic period were dated to around 1135 BC and 1440 BC while the Metal period burials and grave goods were dated to between 3920 ± 270 BP and 790 ± 195 BP (circa 1970 BC and 1160 AD) (Chia and Hassan 2005).
Malaysian Borneo

Niah Cave

Excavations in Niah Cave in Borneo had uncovered the presence of two different occupations with pre-Neolithic and Neolithic contexts (Krigbaum and Datan 2005; Krigbaum and Manser 2005; Majid and Pfister 2005; Barker et al. 2007). The Pre-Neolithic occupation was dated to around 21000-8000 BP (Krigbaum 2003; Krigbaum and Datan 2005; Krigbaum and Manser 2005; Barker et al. 2007; Barker et al. 2011). Primary burials were mainly flexed and “seated” while secondary burials were “mutilated” (Krigbaum and Datan 2005; Krigbaum and Manser 2005; Majid and Pfister 2005; Barker et al. 2011). Primary burials from the Neolithic contexts were buried in an extended position along with associated ceramics and were dated to around 4000 BP (Krigbaum and Datan 2005; Krigbaum and Manser 2005; Majid and Pfister 2005; Barker et al. 2011). Evidence of cremation was also found among the burials from the Neolithic context (Barker et al. 2011). The Mesolithic period in Niah, which is dated to around 11500-8000 BP, was marked with a foraging lifestyle while Neolithic evidence of farming was dated to around 4000-2000 BP (Krigbaum and Manser 2005; Barker et al. 2007; Higham et al. 2009; Barker et al. 2011). Isotope analysis on dental remains of individuals from Niah suggested a change in subsistence between pre-Neolithic and Neolithic from part time foraging and open forest horticulture to plant cultivation (Krigbaum 2003). However, little direct evidence of agriculture was found in the site (Krigbaum and Manser 2005; Barker et al. 2011).

Site from Taiwan: Shi San Hang

Shi San Hang, a prehistoric aboriginal site in Taiwan, yielded several burials from the Iron Age and was dated to around 1800-500 BP (Pietrusewsky and Tsang 2003). The site is located near the mouth of the Danshui River at the northern coast of Taiwan (Pietrusewsky and Tsang 2003). Twenty-three of the skeletons recovered were examined, 15 of whom were males and 8 of whom were females (Pietrusewsky and Tsang 2003). All of the skeletal remains examined were adult and young adults (Pietrusewsky and Tsang 2003).
Bioarchaeological studies on Indonesia consisted mostly on palaeoanthropological research and no reports on modern human remains have been found. Thus, no studies from Indonesia were included in this section.

A summary of the patterns of dental and skeletal pathologies according to region are presented in the following section. The samples were compared according to sites and not according to time periods since most of the individuals from sites spanning two or more time periods were grouped as a single sample in published reports. The general paleodemographic patterns of the individuals from various Southeast Asian samples are also presented.

**Paleodemography**

Studies on paleodemography in Southeast Asia are mainly concentrated in Thailand. This is because archaeological sites in Thailand have yielded large samples for study which are representative of past populations. Also, among all other Southeast Asian countries, “only Thailand shone like a welcoming beacon” to foreign archaeologists for research and is thus the most examined area in the region (Higham 2011, p.639).

The rates of infant mortality were highest among the sites in Thailand dated from the Neolithic and decreased through time, suggesting an improvement in infant health during the transition to the Bronze Age period (Pietrusewsky 1974; Higham and Kijngam 1984b; Higham and Kijngam 1984a; Houghton and Wiriyaromp 1984; Boyd et al. 1998; Higham and Thosarat 1998; O'Reilly 1998; Tayles et al. 1998; Tayles 1999; Pietrusewsky and Toomay...
The rate of infant mortality increased again during the transition to the Iron Age though the rates were not as high as those observed from the Neolithic period sites (Higham and Kijngam 1984a; Houghton and Wiriyaromp 1984; Pietrusewsky and Toomay 2002; Higham and Thosarat 2007h; Higham and Thosarat 2007g; Higham and Thosarat 2007a; Higham and Thosarat 2007b; Higham and Thosarat 2007c; Higham and Thosarat 2007d; Higham and Thosarat 2007e; Higham and Thosarat 2007i; Higham and Thosarat 2007f; Tayles et al. 2007; Boyd et al. 2009; Higham 2009). The rates of young adult mortality were highest among the individuals from the Bronze period sites, particularly in young adult females.

In Khok Phanom Di, infant mortality was highest during the second to third mortuary phases, which was just before the transition from hunting and gathering to agriculture, while an improvement of infant mortality rate was observed from the fourth mortuary phase (Tayles 1999). This trend declined during the later phases, though an increase in child mortality was observed (Tayles 1999). However, the percentage of child mortality is still less compared to the infant mortality during the earlier phases. There was no statistically significant difference in adult mortality through time, and females had a higher mean age at death in all phases (Tayles 1999).

A decline in life expectancy at birth and at fifteen years of age was observed at Ban Chiang (Pietrusewsky and Toomay 2002). The mean age of death also declined over time while birth rate increased which suggested an increase in fertility commonly associated with an agricultural economy (Pietrusewsky and Toomay 2002). The village population in Ban Chiang was either stationary or slightly decreasing with the change in subsistence economy accompanied by the intensification of agriculture during the first millennium BC (Pietrusewsky and Toomay 2002). Status of health was fairly consistent even in the presence of Bronze technology (Pietrusewsky and Toomay 2002).

Based on the burials recovered from the site, it was observed that a high level of fertility occurred during the occupation in Man Bac (Oxenham et al. 2011). This rapidly growing population was associated with a major economic or behavioral shift during this time period such as the intensification of agriculture (Oxenham et al. 2011) A bimodal frequency in subadult mortality was observed, with neonates and infants aged at around 18 months having the highest levels of mortality (Oxenham et al. 2011).
**Diet and Oral Health**

Examining oral health in a particular sample is essential since oral pathologies reflect the staple diet of a population and any subsistence changes would generally result in a change in the prevalence of these pathologies (Dobney and Brothwell 1986; Hillson 1996; Alt et al. 1998). Each type of lesion has different aetiologies, thus making it easier to identify what sort of diet these people had, along with other evidence from the archaeological record such as middens, botanical and animal remains (Dobney and Brothwell 1986; Hillson 1996; Alt et al. 1998; Ortner 2003; Waldron 2009).

Isotope analysis is vital in understanding prehistoric diet and changes in subsistence patterns through the examination of changes in carbon and oxygen isotopes from teeth (Krigbaum 2003; King and Norr 2006). General effects of diet on health can be seen in skeletal remains. These usually include indicators of oral health such as the presence of caries, calculus, and periodontal disease as well as tooth wear (Larsen 1997; Tayles 1999; Larsen 2000; Buikstra and Beck 2006; Agarwal and Glencross 2011).

Rice has been a central part of the diet of Southeast Asians for thousands of years. Rice usually serves as the staple and is generally supplemented with vegetables and seafood or animal protein. The earliest evidence of rice agriculture within Southeast Asia was dated to around 2300 BC and was found in Thailand (Bellwood 2005). This transition from hunting and gathering to an agricultural lifestyle would have had an impact on health with the change of diet in the population (Higham 1995; Tayles et al. 2000; Bentley et al. 2005; Temple 2010; Barker et al. 2011). Studies on oral health of hunter-gatherers have revealed that these people typically have low frequencies of caries, calculus, malocclusion, and alveolar resorption but have high frequency of severe attrition (Larsen 1995; Cohen and Crane-Kramer 2007; Cucina et al. 2011). On the other hand, the profile of agricultural populations is generally the opposite of hunter-gatherers, with low rates of severe attrition and high rates of caries, calculus, resorption and dental crowding (Larsen 1995; Cohen and Crane-Kramer 2007; Cucina et al. 2011). However, the profile of agricultural populations in Southeast Asia does not follow this general pattern (Tayles 1999; Tayles et al. 2000; Oxenham et al. 2006; Cohen and Crane-Kramer 2007). Based on the dental profile of skeletal samples from Thailand, it has been shown that even after the transition to agriculture the dental pathology profile of the skeletal samples from this region was generally consistent with a broadly based subsistence system which is common among hunter-gatherer populations (Houghton and Wiriyaromp 1984; Tayles et al. 1998; Tayles et al. 2000; Domett 2001; Domett 2004; Douglas 2006;
Tayles et al. 2007). While the transition from hunting and gathering to agriculture had a negative impact on oral health of other populations, current research on Southeast Asian skeletal remains suggests an improvement of oral health with the transition to agriculture (Oxenham et al. 2006; Cohen and Crane-Kramer 2007). This deviation from the normal pattern has been attributed to the fact that rice is not as cariogenic as other crops that were used as staples by other agricultural populations (Tayles 1999; Oxenham et al. 2006).

**Oral Pathologies**

This section presents a summary of the oral pathologies found in skeletal samples from Southeast Asia.

**Caries**

Caries refer to the destruction of teeth due to bacterial processes from food left on teeth (Hillson 1996; Alt et al. 1998). These are usually manifested as holes in different parts of the teeth (Hillson 1996). A more detailed description of caries and its aetiology is discussed in Chapter 3.

Among the sites from southeast Thailand, a low to moderate prevalence of caries was observed (Tayles et al. 1998; Tayles 1999). In Khok Phanom Di, the time period during the transition from foraging to agriculture correlated with the decline in the prevalence of caries among the individuals from the site (Tayles 1999). The decline of abrasions on the teeth through time also suggests a shift in diet to more non-abrasive food types (Tayles 1999). Among all the sites from southeast Thailand, the individuals from Khok Phanom Di had the highest prevalence of caries (Tayles et al. 1998; Tayles 1999). Caries was generally more prevalent among females than males on all sites from central Thailand (Tayles et al. 1998; Tayles 1999). A general decrease in prevalence with age was observed among the individuals from Khok Phanom Di compared to later sites (Tayles et al. 1998; Tayles 1999). Among the individuals from Nong Nor, no difference in prevalence according to adult age was observed (Tayles et al. 1998).

A generally low prevalence of caries was also observed among the individuals from the northeast Thailand sites except those from Noen-U-Loke, where a moderate prevalence was seen (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Domett 2001; Pietrusewsky and Toomay 2002; Domett 2004; Tayles et al. 2007). Overall, caries was more prevalent among females than males, and a general increase in prevalence with age was observed. (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Domett 2001; Pietrusewsky and
Among the individuals from several sites in northern Vietnam, the prevalence of caries was generally low (Oxenham et al. 2002; Oxenham et al. 2006; Oxenham et al. 2011). However, a moderate prevalence was observed in the individuals from the Neolithic site of Man Bac (Oxenham et al. 2011). In general, caries was more prevalent in females than males except for Man Bac where the reverse was true (Oxenham et al. 2002; Oxenham et al. 2006; Oxenham et al. 2011). Among the samples from the Red River, caries was observed only in females and none was seen on males (Oxenham et al. 2002; Oxenham et al. 2006).

Low frequencies of dental caries, antemortem tooth loss, dental abscessing and evidence of periodontal disease were observed in the individuals from Shi San Hang (Pietrusewsky and Tsang 2003). This suggested a mixed economy of both plant cultivation and hunting-gathering (Pietrusewsky and Tsang 2003).

The prevalence of caries among the individuals from the Hoabinhian period in Gua Cha was higher than those from the Neolithic period, suggesting a decline in prevalence through time (Bulbeck 2005a). A similar prevalence to the Hoabinhian individuals from Gua Cha was seen among the individuals from Guar Kepah (Bulbeck 2005b).

**Calculus**

Dental calculus is calcified dental plaque caused by the accumulation of minerals on the teeth (Hillson 1996; Alt et al. 1998). In archaeological samples, dental calculus can be difficult to identify due to other deposits on teeth due to soil composition and dental preservation (Hillson 1996). Calculus can be removed easily by taphonomic processes as well and may not be observed on some teeth (Hillson 1996; Alt et al. 1998).

Among the sites from northeast Thailand, a moderate prevalence of calculus was observed (Pietrusewsky 1974; Pietrusewsky and Toomay 2002; Domett 2004). Calculus was not recorded for the individuals from Noen-U-Loke due to the amount of calcareous deposition in some teeth which prevented an accurate recording of the presence of calculus (Tayles et al. 2007). Calculus was also not recorded for the individuals from Ban Na Di (Houghton and Wiriyaromp 1984). A higher prevalence in females was seen in the samples from Non Nok Tha while among the individuals from Ban Chiang, there were slightly more males than females with caries (Pietrusewsky 1974; Pietrusewsky and Toomay 2002).
A decline in the prevalence of calculus through time was observed among the individuals from Gua Cha (Bulbeck 2005a). Like the prevalence of caries, the prevalence of calculus among the Guar Kepah individuals was similar to the Hoabinhian individuals from Gua Cha (Bulbeck 2005b).

**Periapical Lesions**

Periodontal disease refers to the formation of soft tissue pockets between gums and tooth root resulting in the loosening of tooth and eventual tooth loss (Hillson 1996; Alt et al. 1998). Periapical cavities result from periodontal disease and can be classified into three categories: (1) granulomas are small cavities, usually less than three millimeters in diameter, with smooth walls and circumscribed cavity margins (Hillson 1996; Alt et al. 1998); (2) cysts are similar to granuloma but are generally greater than three millimeters in diameter (Hillson 1996; Alt et al. 1998); and (3) abscesses are generally larger cavities that can extend to the alveolar margins and are marked with roughened walls (Hillson 1996; Alt et al. 1998).

Overall, the prevalence of periapical lesions among the samples from southeast Thailand was low (Tayles et al. 1998; Tayles 1999). Slightly more females than males had periapical lesions in the sample from Khok Phanom Di (Tayles 1999). A general increase in prevalence with age was observed among the individuals from Khok Phanom Di (Tayles 1999).

A generally low prevalence was also observed among the individuals from the northeast Thailand samples. Periapical lesions were more prevalent in males than females in all samples except the ones from Noen-U-Loke where females were more affected (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Domett 2001; Pietrusewsky and Toomay 2002; Domett 2004; Tayles et al. 2007). However, the males with evidence of infection had more lesions than females. A general increase in prevalence with age was also observed (Pietrusewsky 1974; Domett 2001; Pietrusewsky and Toomay 2002; Domett 2004; Tayles et al. 2007). Among the individuals from Ban Lum Khao, an increase in the prevalence of periapical lesions with age was seen in males while the inverse was seen in females (Domett 2004).

The prevalence of periapical lesions among the samples from northern Vietnam was low overall. Among the Neolithic sites Man Bac and Da But, periapical lesions were more prevalent in males than females while the opposite is true for the Metal period sites from the Ma, Ca and Red Rivers (Oxenham et al. 2002; Oxenham et al. 2006; Oxenham et al. 2011).
However, the difference in prevalence between the sexes was not statistically significant. The prevalence of periapical lesions increased with age among the individuals from Man Bac (Oxenham et al. 2011).

An increase in the prevalence of periapical abscesses through time was observed among the individuals from Gua cha, while the prevalence of abscesses from the Guar Kepah individuals was similar to the Hoabinhian individuals from Gua Cha (Bulbeck 2005a; Bulbeck 2005b).

*Alveolar Resorption*

Severe periodontal disease results in the destruction of gums and resorption of the alveolar margins of the teeth (Hillson 1996; Alt et al. 1998). The resorption of bone sometimes leads to the exposure of the neck and roots of the teeth (Hillson 1996).

The prevalence of alveolar resorption in the individuals from the southeast Thailand sites was not recorded. Among the samples from northeast Thailand, a low to moderate prevalence of alveolar resorption was observed (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Pietrusewsky and Toomay 2002; Domett 2004; Tayles et al. 2007). Alveolar resorption was more prevalent in males than females except in Non Nok Tha, where resorption is found in more females than males (Pietrusewsky 1974). However, none of the differences according to sex were statistically significant. The prevalence of alveolar resorption was not presented in the oral health studies on the northern Vietnam samples.

A decline in the prevalence of alveolar resorption through time was seen among the individuals from Gua Cha (Bulbeck 2005a). The prevalence of alveolar resorption among the Guar Kepah individuals was similar to the Hoabinhian individuals from Gua Cha (Bulbeck 2005b).

*Antemortem Tooth Loss (AMTL)*

Antemortem tooth loss refers to the loss of teeth while the individual is still alive (Hillson 1996; Alt et al. 1998). Evidence of remodelling of the tooth sockets can be observed among individuals with antemortem tooth loss (Hillson 1996).

A low to moderate prevalence of AMTL was observed among the individuals from southeast Thailand (Tayles et al. 1998; Tayles 1999). A higher prevalence in females than males was seen on individuals from both of the southeastern Thailand sites (Tayles et al. 1998; Tayles 1999).
Overall, a low prevalence of AMTL was seen among the individuals from the northeast Thailand sites. AMTL was more prevalent in males than females on all sites except in Ban Na Di where the reverse was true (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Pietrusewsky and Toomay 2002; Domett 2004; Tayles et al. 2007). A general increase in the prevalence of AMTL with age was observed. Among the individuals from Non Nok Tha, a slightly higher prevalence of AMTL of the incisors, canines and premolars was seen in females, while the males had a higher prevalence of AMTL on the molars (Pietrusewsky 1974).

The prevalence of AMTL among the individuals from northern Vietnam was also low. AMTL was more prevalent in females than males among the individuals from all the different sites (Oxenham et al. 2002; Oxenham et al. 2006; Oxenham et al. 2011). The differences in prevalence according to sex were not statistically significant. An increase in prevalence with age was observed among the individuals from Man Bac (Oxenham et al. 2011).

*Attrition*

Dental attrition refers to the wearing of tooth’s enamel which results in the exposure and destruction the dentin (Hillson 1996; Alt et al. 1998).

The prevalence of advanced attrition among the samples from southeast Thailand was low. A higher prevalence among males than females was observed from the samples, and a general increase in prevalence with age was seen (Tayles et al. 1998; Tayles 1999).

A moderate prevalence of advanced attrition was observed among the individuals from Noen-U-Loke and Non Nok Tha (Pietrusewsky 1974; Tayles et al. 2007). Among the individuals from Ban Chiang, a high prevalence of attrition was seen while a low prevalence was observed in the individuals from the Ban Na Di sample (Houghton and Wiriyaromp 1984; Pietrusewsky and Toomay 2002). A higher prevalence in males than females was seen among the individuals from Noen-U-Loke and Ban Chiang while the opposite was seen in the individuals from Non Nok Tha and Ban Na Di (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Pietrusewsky and Toomay 2002; Tayles et al. 2007). However, the differences in prevalence according to sex were not statistically significant. An increase in prevalence of attrition with age was observed on the samples from Noen-U-Loke and Ban Na Di (Houghton and Wiriyaromp 1984; Tayles et al. 2007).
The prevalence of advanced attrition in the northern Vietnam samples was not presented in the published oral health studies from the region.

Advanced attrition was found to be more prevalent in females in Shi San Hang, which implied a difference in access to adequate resources between sexes (Pietrusewsky and Tsang 2003). However, the sample was rather small and might not be representative of the past population.

More individuals from the Hoabinhian period had advanced attrition than those from the Neolithic period in Gua Cha (Bulbeck 2005a). Like the prevalence of other oral pathologies, the overall prevalence of advanced attrition among the Guar Kepah individuals resembled the prevalence of the Hoabinhian individuals from Gua Cha (Bulbeck 2005b).

*Oral Pathologies and Health*

High prevalence of oral pathologies within populations generally indicate poor oral health (Hillson 1996; Alt et al. 1998). These oral pathologies have different aetiologies. Caries, alveolar resorption and periapical lesions are commonly due to infection while calculus is formed through the deposition of mineralized bacteria on teeth (Hillson 1996; Alt et al. 1998). Antemortem tooth loss can indicate tooth removal due to infection or other complications but may also be due to deliberate ablation as part of a cultural custom (Hillson 1996). The prevalence of these pathologies can also reflect the diet of past populations since particular types of food tend to cause certain kinds of oral pathologies (Hillson 1996; Alt et al. 1998).

*Isotope Analysis*

Stable isotope analyses from bone and tooth samples are useful in reconstructing the diet of past populations (Ambrose 1993; Ambrose and Katzenberg 2000). Isotopic compositions of chemical elements of different foods such as plants, terrestrial animals and marine foods consumed by an individual are examined and any differences in the prevalence of isotopic signatures found among the individuals indicate shifts in consumption patterns of food varieties (Ambrose 1993; Ambrose and Katzenberg 2000). Analysis of carbon, nitrogen and oxygen isotopes are commonly used in paleodiетary studies (Ambrose 1993; Ambrose and Katzenberg 2000).

Stable isotopic analysis of carbon and nitrogen in skeletal samples from northeast Thailand revealed a change in diet through time (King and Norr 2006; King 2008). An
increase in consumption of domesticated animals and wet rice was found among individuals from later mortuary phases (King and Norr 2006; King 2008). Differences in isotopic values according to sex were also observed, which is similar to the isotopic evidence found in skeletal samples from Khok Phanom Di (King and Norr 2006; Bentley et al. 2007; King 2008).

A change in subsistence pattern from pre-Neolithic to the Neolithic period was found among the individuals from Niah Cave by using stable carbon isotope analysis from tooth samples (Krigbaum 2003; Krigbaum and Manser 2005). A shift towards higher consumption of marine foods was seen among the individuals from the Neolithic period (Krigbaum 2003; Krigbaum and Manser 2005).

**Growth and Disruptions of Growth**

The human skeleton undergoes many changes from birth to adulthood. The formation of new bone to replace cartilage and fusion of cranial, vertebral and long bone elements occur during an individual’s growth period (Massaro and Rogers 2004; Scheuer and Black 2004; White and Folkens 2005). However, abnormal change in bone occurs as a response to disease and malnutrition.

**Non-specific Indicators of Stress**

Non-specific indicators of stress include general markers of growth disruption and inadequate nourishment of individuals (Larsen 1997; Larsen 2000; Buikstra and Beck 2006; Waldron 2009). Growth is a primary indicator of health in prehistoric populations (Bogin 1999; Waldron 2009). Disruption of growth recorded in bone and teeth suggests poor health and its prevalence within the population can be an indicator of subgroups with differing socioeconomic benefits (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Indicators of growth disruption include the presence of Harris lines, linear enamel hypoplasia and having a small vertebral neural canal size (Goodman and Rose 1991; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; King et al. 2005; Watts 2011). Among adults, the calculation of stature from long bone lengths indicates the achievement of growth potential within the population (White and Folkens 2005; Buikstra and Beck 2006; Waldron 2009). Since growth and nutrition are closely correlated, average adult stature can be used as an indicator of population health (Bogin 1999; Goodman and Martin 2002). Differences in
sexual dimorphism through time within a population can be used as an indicator of differences in overall health between males and females (Buikstra and Beck 2006).

Harris lines of arrested growth are dense, opaque transverse lines seen on radiographs of long bones, particularly on the tibiae (Larsen 1997; Larsen 2000). These lines correspond to the periods of stress during an individual’s growth and can only occur during the growth period. Linear enamel hypoplasia (LEH) refer to the bands of transverse lines on the enamel of the teeth due to “deficiencies in matrix composition” (Goodman and Rose 1991, p.281) while the teeth are developing (Hillson 1996; Alt et al. 1998). The aetiology of these skeletal and dental defects is mainly attributed to malnutrition resulting from dietary deficiencies during an individual’s growth period. Another non-specific indicator of stress is cribra orbitalia, the lytic lesions found on the roof of the orbits which are sometimes accompanied by some spongy bone formation (Larsen 1997; Larsen 2000; Buikstra and Beck 2006; Waldron 2009; Oxenham and Cavill 2010). Due to the complicated nature of the aetiology of this skeletal lesion, a more detailed discussion on the prevalence of cribra orbitalia is discussed under the section on non-specific indicators of stress in Chapter 3.

_Harris Lines and Linear Enamel Hypoplasia_

Harris lines were examined in some samples from Khok Phanom Di and no significant difference in prevalence according to sex was found (Tayles 1999). No reports on Harris lines from the Nong Nor remains were published. The prevalence of linear enamel hypoplasia in subadults was higher among the Nong Nor individuals than the samples from Khok Phanom Di, while the reverse was true for the prevalence in adults (Tayles et al. 1998; Tayles 1999). LEH was more common among the individuals from the early and late mortuary phases in Khok Phanom Di (Tayles 1999). For both samples from southeast Thailand, LEH was more prevalent in females than males, though the differences between sexes were not statistically significant (Tayles et al. 1998; Tayles 1999).

The prevalence of LEH among the individuals from the northeast Thailand sites was higher than those from the southeast Thailand samples. LEH was more prevalent in subadults than adults among the northeast Thailand individuals (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Tayles et al. 1998; Domett 2001; Domett 2004; Tayles et al. 2007). However, the high number of individuals with advanced attrition in some sites, particularly in Noen-U-Loke, might have had an effect on the observed prevalence of LEH (Tayles et al. 2007). For most of the northeast Thailand sites, LEH was more prevalent in males than
females with the exception of the individuals from Ban Lum Khao and Non Nok Tha (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Tayles et al. 1998; Domett 2001; Domett 2004; Tayles et al. 2007). A general transition in the prevalence of LEH through time from females to males was observed (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Tayles et al. 1998; Domett 2001; Domett 2004; Tayles et al. 2007). LEH was more prevalent in females for the majority of the sites dated to the Neolithic while among those dated to the Iron Age, LEH was present in more males than females (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Tayles et al. 1998; Domett 2001; Domett 2004; Tayles et al. 2007).

Linear enamel hypoplasia was found to be more prevalent in females than males in Man Bac, Vietnam (Oxenham et al. 2011). Younger females were particularly more affected, and overall younger individuals were more affected than older individuals (Oxenham et al. 2011).

In the site of Gua Cha situated in peninsular Malaysia, a high prevalence of linear enamel hypoplasia was observed though no apparent difference in prevalence during the transition from foraging to agriculture was seen (Bulbeck 2005a). A lower prevalence of LEH in canines and third molars was seen from the Guar Kepah samples compared to the teeth from Gua Cha (Bulbeck 2005b).

A high frequency of enamel hypoplasia and cribra orbitalia was observed among the individuals from Shi San Hang (Pietrusewsky and Tsang 2003). Both LEH and cribra orbitalia were more prevalent in females than males (Pietrusewsky and Tsang 2003).

A study of localized enamel hypoplasia of the primary canine (LHPC) was conducted using samples from seven sites in Thailand spanning a time frame of 4000-1500 BP (Halcrow and Tayles 2008). Among the sites included are Ban Na Di, Non Nok Tha, Ban Chiang, Ban Lum Khao, Noen-U-Loke, Muang Sema and Khok Phanom Di (Halcrow and Tayles 2008). All are located inland with the exception of Khok Phanom Di. A high occurrence of caries was found to be associated with localized enamel hypoplasia of the primary canine (Halcrow and Tayles 2008). Since LHPC develops during the formation of the deciduous canine which takes place in utero, the high occurrence of localized enamel hypoplasia in these sites may be linked to poor maternal and infant health (Halcrow and Tayles 2008).

**Stature**

Adult stature is a result of many different biological and environmental factors. Though biological factors such as genetics do have an effect on stature, genetic differences
“approximately cancel out in comparisons of averages across most populations, and in these situations heights accurately reflect health status” (Steckel 1995, p.1903). Average stature of adults in populations from similar time periods but from different regions can be compared to determine if any differences can be attributed to environmental factors (Steckel 1995; Bogin 1999; Roberts and Manchester 2005). Reduced stature may indicate inadequate nutrition and elevated levels of stress during growth (Bogin 1999; Roberts and Manchester 2005). However, a ‘catch-up’ period of growth can occur among individuals with suppressed growths as juveniles (Huss-Ashmore et al. 1982; Bogin 1999). While a less-than-average stature for subadults can indicate an immediate condition of poor nutrition and health, reduced adult stature is likely to be due to a chronic condition (Goodman and Martin 2002). Research on human growth has shown that a combination of hereditary and environmental interactions account for the population variations in stature. Environmental factors such as altitude and climate have been correlated with growth. Prenatal growth retardation was observed among juveniles from high altitudes (Lichty et al. 1957; Hass et al. 1980) while seasonal rates of growth were seen among subadults from both temperate and equatorial climates (Scammon 1927; Marshall and Swan 1971; Marshall 1975; Bogin 1978; Satake et al. 1994; Bogin 1999).

Among the sites from southeast Thailand, the individuals from Nong Nor were on average taller than those from Khok Phanom Di (Tayles et al. 1998; Tayles 1999). The difference in mean stature for males between the two sites was statistically significant but not for females (Tayles et al. 1998; Tayles 1999). The individuals from Nong Nor were more sexually dimorphic than those from Khok Phanom Di (Tayles et al. 1998; Tayles 1999). The variation in stature and sexual dimorphism between the two sites can be attributed to the difference in access to resources of the two populations or genetic factors (Domett 2001; Domett and Tayles 2006a). The Bronze Age period individuals might have had better health due to the development of more sophisticated devices and equipment for food manufacturing compared to those who lived during the Neolithic period.

The individuals from Non Nok Tha had the highest mean stature from the northeast Thailand sites (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Tayles et al. 1998; Domett 2001; Domett 2004; Tayles et al. 2007). However, this may very likely be due to the difference in the formulas used for calculating stature (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Tayles et al. 1998; Domett 2001; Domett 2004; Tayles et al. 2007). The statures of the individuals from Non Nok Tha were calculated using the formulas by Trotter and Gleser (1958) which were based mainly from Caucasian samples (Bayard 1971). On the other hand, the heights of the individuals from all the other northeast Thailand sites were
calculated using the formulas developed by Sangvichien et al. (1985) from modern Thai and Chinese cadavers which is more appropriate for estimating statures of individuals from Southeast Asia (Houghton and Wiriyaromp 1984; Tayles et al. 1998; Domett 2001; Domett 2004; Tayles et al. 2007). The individuals from Non Nok Tha also had the most difference between the mean statures of males and females, with the individuals from Ban Lum Khao having the second most sexually dimorphic mean stature among the northeast Thailand sites (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Tayles et al. 1998; Domett 2001; Domett 2004; Tayles et al. 2007). Apart from the Non Nok Tha samples, the individuals from the sites dated to the later periods generally had higher mean statures than those from the earlier sites (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Tayles et al. 1998; Domett 2001; Domett 2004; Tayles et al. 2007). The wide range of stature among individuals in Ban Lum Khao suggested the presence of a hierarchical society where access to food resources is unequal (Domett 2004; Domett and Tayles 2006a). However, no archaeological evidence of a hierarchical society was found (Cameron et al. 2004). Another plausible explanation for the wide range of stature is genetic heterogeneity (Domett 2004; Domett and Tayles 2006a). Evidence from isotope analysis suggested the immigration of foreigners into local populations in Thailand during the transition to agriculture (Bentley et al. 2005; Bentley et al. 2007), while other studies indicated a low level of immigration during the Iron Age in northeast Thailand (Cox et al. 2011). The differences in average stature within the samples make the comparison of health with other samples complicated.

The mean stature from the individuals from Shi San Hang was found to be higher than the mean stature from current aboriginal population in Taiwan (Pietrusewsky and Tsang 2003).

An increase in stature over time was seen among the individuals from Niah Cave (Majid and Pfister 2005). Individuals from the Neolithic had a higher average stature than those from the pre-Neolithic burials (Majid and Pfister 2005). In Guar Kepah, the average height of the individuals examined was similar to other samples from the Holocene period in peninsular Malaysia and also those from Khok Phanom Di (Bulbeck 2005b).

*Lifestyle and Activities*

Lifestyle and activity patterns are interpreted through the examination of musculoskeletal markers, enthesopathies and stress indicators in skeletal remains (Weiss 2003; Weiss 2007). Musculoskeletal markers refer to the roughened parts of the skeleton where muscles are attached while enthesopathies refer to a disorder of these attachments
(Robb 1998; Weiss 2003; Niinimaki 2011; Weiss et al. 2012). The distribution and degree of development of these markers in the skeleton helps in determining activity patterns of individuals. The distribution of these activity indicators in the skeleton are then differentiated according to sex and age group to determine which members of the population show signs of stress in different parts of the body and the activities that were highly likely to have contributed to these skeletal manifestations. Numerous studies have indicated a correlation between activity and the presence of well-developed musculoskeletal markers and enthesopathies (Weiss 2007; Lieverse et al. 2009; Villotte et al. 2010; Havelkova et al. 2011; Molnar et al. 2011). However, correlations between activity patterns and musculoskeletal markers are not always straightforward. Numerous other factors such as genetic predisposition, height, weight, age and sex are also involved in the development of musculoskeletal markers and stress indicators such as osteoarthritis and degenerative joint disease (Resnick 1995; Jurmain 1999; Weiss 2003; Mariotti et al. 2004; Mariotti et al. 2007; Weiss 2007; Curtis 2008; Alves Cardoso and Henderson 2010; Villotte et al. 2010; Niinimaki 2011; Weiss et al. 2012). However, marked differences of these markers between sex and age group can indicate the specialization of certain sets of activities in a population (Waldron 1994; Jurmain 1999).

**Joint Degeneration**

Several reports on joint pathologies of the individuals from different sites in Thailand had not differentiated between joint degeneration due to normal wear and tear usually associated with age (Degenerative Joint Disease) and joint pathologies which may be caused by excessive activity and stress on joints (osteoarthritis) (Resnick 1995; Rogers and Waldron 1995; Jurmain 1999; Waldron 2001). These reports used the terms joint degeneration and osteoarthritis interchangeably which made it difficult to differentiate the joint pathologies which were most likely due to activity and those caused by the degeneration of the articular joints as a consequence of aging. Thus, the reports on these individuals are included under the joint pathologies section of this chapter. The individuals included in this section are from the reports on joint pathologies which were likely caused by activity and stress.

In Khok Phanom Di, the loss of marine access during the second period of occupation of the site led to a change in activities for the settlers (Tayles 1999). The reduction of prevalence of osteoarthritis on the upper body during the fourth mortuary phase indicated a decline in activities such as fishing and canoeing (Tayles 1999). The prevalence of osteoarthritis among the individuals from Khok Phanom Di was higher compared to those
from Nong Nor. However, the relatively poorer preservation of joints from the Nong Nor samples meant that the few observable joints might have skewed the prevalence of osteoarthritis within the population (Tayles et al. 1998).

**Trauma**

Evidence of trauma can be identified from skeletal remains by examining antemortem lesions, that is, injuries that occurred before death. The fundamental difference between antemortem, perimortem and postmortem lesions is the presence of healing on bone (Gentry Steele and Bramblett 1988; Sauer 1998; Massaro and Rogers 2004; Scott 2008). This is not always observable particularly in archaeological specimens where the remains have been compromised by taphonomic changes. The key to identifying skeletal lesions caused by taphonomic actions versus lesions that occurred during life is the appearance of the edges of the lesions. Antemortem lesions have smoother edges due to remodelling while the edges of postmortem lesions are sharp and no evidence of remodelling is present (Gentry Steele and Bramblett 1988; Sauer 1998; Jurmain 1999; Katzenberg and Saunders 2000; Larsen 2000; Massaro and Rogers 2004; Scott 2008). High frequencies of injuries in a population may suggest warfare or violence either within a group or with other groups (Scott 2008). These injuries also help in identifying an individual’s role during life.

Evidence of trauma in the samples from southeast Thailand was very minimal. Fractures were mostly found on the post-cranial region, with only one individual from Nong Nor having a fracture on the mandible (Tayles et al. 1998). All fractures seem to be the result of accidental injury and no evidence of interpersonal violence was found on the two sites (Tayles et al. 1998; Tayles 1999).

More evidence of trauma was found among the northeast Thailand samples compared to those from the southeastern region, particularly those from Ban Chiang. Trauma on the upper limbs was most common among the individuals from Ban Lum Khao and Non Nok Tha while among those from Ban Chiang, rib fractures were more common (Pietrusewsky 1974; Pietrusewsky and Toomay 2002; Domett 2004). A higher prevalence of upper limb trauma in males was observed among the Ban Lum Khao samples (Domett 2004). These patterns of trauma suggested a strenuous lifestyle particularly among males where accidental injury was common. Evidence of interpersonal violence was found among the individuals from Noen-U-Loke in the form of an iron projectile lodged on the 12th thoracic and 1st lumbar vertebrae of a young adult male (Tayles et al. 2007).
An examination of a skeletal sample from Phum Snay in north-western Cambodia revealed an unusually high occurrence of traumatic injuries particularly to the head suggesting interpersonal violence (Domett et al. 2011). The site was dated to the Iron Age at around 350 BC- AD 200 though no precise dating has been done on the site (Domett et al. 2011). Swords and other weapons were found amongst the burials. The study found that twice as many males than females exhibited traumatic lesions. It was also found that the right hand side was more affected, though the results were not statistically significant. Injuries were found more frequently on the parietal than the frontal and occipital. This pattern of traumatic lesions indicated the presence of conflict during the emergence of polities in the region before the domination of Angkor (Domett et al. 2011).

Spondylolysis was found in three individuals from Shi San Hang, though other forms of trauma were not observed from the sample (Pietrusewsky and Tsang 2003).

**Skeletal Pathologies**

Diagnosing disease in skeletal remains is a very difficult task. This is because the changes that are manifested in bone due to disease are very limited. Lesions on bone caused by disease are commonly classified into two groups: osteoblastic and osteolytic (Massaro and Rogers 2004; White and Folkens 2005; Buikstra and Beck 2006). Osteoblastic lesions are lesions due to an excess of osteoblasts around the affected area which leads to bone proliferation (Mays 1998; White and Folkens 2005; Buikstra and Beck 2006). Osteolytic lesions are caused by osteoclasts which are responsible for the resorption of bone (Mays 1998; White and Folkens 2005; Buikstra and Beck 2006). One or a combination of these lesions can be found on bone afflicted with disease. The distribution of these lesions in the skeleton helps in determining the underlying condition of an individual (Steinbock 1976; Ortner and Putschar 1985; Waldron 2009). Epidemiology of certain diseases can be determined by the distribution of these lesions within the population (Waldron 1994; Waldron 2007).

Not all diseases can be diagnosed from the skeleton. Because the soft tissue has already decomposed and the skeletal remains are all that is left for study, the bioarchaeologist has to determine an individual’s disease based on incomplete data. Some diseases do not manifest signs in the skeleton, while other individuals might have succumbed from disease before it has affected the bone and will thus not be visible on the skeletal remains (Steinbock 1976; Ortner and Putschar 1985; Rogers et al. 1987; Wood et al. 1992; Rodriguez-Martin 2006; Waldron 2009). Different diseases that can be identified from skeletal remains include
infectious diseases such as treponemal diseases and tuberculosis, tumors, metabolic diseases such as osteoporosis and rickets, joint diseases, abnormal bone growth such as dwarfism and gigantism, and oral diseases such as caries and periodontal disease (Steinbock 1976; Ortner and Putschar 1985; Waldron 2009).

Joint Pathologies

Since the joint degeneration related to activity and lifestyle was already summarized in the previous section, the joint pathologies mentioned in this section are from the sites where joint lesions due to activity and normal degeneration due to age were not differentiated. Joint pathologies commonly associated with aging are also reviewed in this section.

Joint degeneration was observed on all joints among the Khok Phanom Di samples. Degenerative changes on the vertebrae were most commonly found on the vertebral bodies, and it was observed that males developed these degenerative changes at an earlier age than females. (Tayles 1999) Degeneration of the vertebral bodies was more prevalent in males than females overall, though more females exhibited degeneration on the lumbar region than males (Tayles 1999). Ankylosis was found on the hand joints of two individuals. The most affected joints on the appendicular skeleton were the shoulders, hands, knees, ankles and feet with the hip joints being the least affected, which was similar to that observed from the Nong Nor individuals (Tayles et al. 1998; Tayles 1999). Among the individuals from Nong Nor, joint degeneration on the hips was not observed, although this may be attributed to the very few observable hip joints from the sample (Tayles et al. 1998).

Among the northeast Thailand sites, the individuals from Ban Lum Khao had the highest prevalence of joint degeneration followed by those from Ban Na Di (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Pietrusewsky and Toomay 2002; Domett 2004; Tayles et al. 2007). Overall, degenerative changes were more prevalent among males than females in all sites. However, among the individuals from Ban Lum Khao and Ban Na Di, a higher prevalence of osteoarthritis was found in females over 30 years of age compared to males from the same age (Houghton and Wiriyaromp 1984; Domett 2001; Domett 2004). Joint degeneration on the vertebrae was most commonly found on the lumbar region in all sites. Among the individuals from Ban Lum Khao, the elbow joint was the most frequent site for osteoarthritis of the upper limbs, while OA on the wrists was more common among the Ban Na Di individuals (Houghton and Wiriyaromp 1984; Domett 2001; Domett 2004). For the lower limbs, osteoarthritis was more prevalent on the foot joints for the Ban Lum Khao,
Ban Chiang and the Ban Na Di samples overall (Houghton and Wiriyaromp 1984; Pietrusewsky and Toomay 2002; Domett 2004). However, among the females of Ban Lum Khao, OA on the lower limbs was most commonly found on the hip joints (Domett 2004). Degenerative disc disease was observed on six individuals from Ban Chiang and was most commonly found on the lower cervical and upper thoracic region of the vertebrae (Pietrusewsky and Toomay 2002). The prevalence of Schmorl’s nodes in Ban Chiang was very minimal, although this may be due to the poor preservation of vertebral bodies within the sample (Pietrusewsky and Toomay 2002). Evidence of Schmorl’s nodes from other sites was not included in written reports and publications.

Degenerative joint disease was absent among the individuals from Shi San Hang, though this is likely due to the sample consisting mostly of young adults (Pietrusewsky and Tsang 2003).

Possible scoliosis and skeletal symptoms of cerebral palsy such as the thinning of long bone shafts and joint deformities were observed from the Perak Man in Malaysia (Matsumura and Majid 2005).

Pathologies from Infectious Diseases

Diagnosing infectious diseases from skeletal remains is a very difficult task since very few infectious diseases leave marks on bone (Steinbock 1976; Ortner and Putschar 1985; Rogers and Waldron 1989; Jurmain 1999; Mays 2008; Waldron 2009). Most infectious diseases primarily affect the soft tissues and it is usually only in severe cases that the skeleton is involved (Steinbock 1976; Ortner and Putschar 1985; Rogers and Waldron 1989). Common examples of infectious diseases that affect the bone include osteomyelitis, syphilis, tuberculosis, leprosy and polio.

In Khok Phanom Di, skeletal pathologies suggested a reduction of exposure to malaria through time (Tayles 1996; Tayles 1999). Infants were more affected with skeletal pathologies during the earlier phases, and from the third mortuary phase onwards evidence indicated that infants with anemia survived into at least childhood (Tayles 1996; Tayles 1999). Minimal skeletal pathology other than joint degeneration was observed among the individuals from the southeast Thailand sites. Among the more common skeletal pathologies of adults were lesions on the lower limbs due to periostitis and lesions on the maxillae and mandible due to dental infections (Tayles et al. 1998; Tayles 1999).
Skeletal lesions on the lower limbs due to periostitis were also the most common pathology from the northeast Thailand samples (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Pietrusewsky and Toomay 2002; Domett 2004; Tayles et al. 2007). These lesions were observed mainly on adults, though some subadults exhibited similar lesions as well. Evidence of possible leprosy and tuberculosis was found among some individuals from Noen-U-Loke (Tayles and Buckley 2004; Tayles et al. 2007). In Ban Chiang, an increase in individual frequency of infection over time was observed (Pietrusewsky and Toomay 2002).

In Shi San Hang, no evidence of general or specific infectious disease was found (Pietrusewsky and Tsang 2003).

Pathologies from Metabolic Diseases

Metabolic diseases refer to those that interfere with the proper metabolism of the body (Steinbock 1976; Ortner and Putschar 1985; Jurmain 1999; Mays 2008; Waldron 2009). Diseases due to hormonal imbalances also fall within this category. These include osteoporosis, rickets and osteomalacia, anemia, scurvy, and Paget’s disease among others. Skeletal pathologies that are due to metabolic diseases include cribra orbitalia, porotic hyperostosis and thickening of the cortical bone.

Cribra orbitalia are ‘holes’ on the surface of the orbital roofs which may be accompanied with the formation of spongy bone (Steinbock 1976; Ortner and Putschar 1985; Waldron 2009). These are caused by the expansion of the diploë or spongy bone to increase red blood cell production and are commonly used as indicators of iron-deficiency anemia along with the porotic hyperostosis of the skull (Steinbock 1976; Ortner and Putschar 1985; Jurmain 1999; Waldron 2009; Oxenham and Cavill 2010). However, the aetiology of these pathologies is not limited to iron-deficiency anemia (Walker et al. 2009). Studies have indicated that different aetiologies such as infectious diseases, scurvy, vitamin B12 deficiency and megaloblastic anemia may produce these lesions (Oxenham and Cavill 2010). Porotic hyperostosis refers to the expansion of the spongy marrow of the skull which results in the spongy appearance of the bone (Steinbock 1976; Ortner and Putschar 1985; Waldron 2009).

Among individuals from the southeast Thailand sites, cribra orbitalia was observed on a few individuals. More children than adults were affected in Khok Phanom Di while in Nong Nor, only adults had evidence of cribra orbitalia, though this is likely due to the difference in preservation of skeletal remains from the two sites (Tayles et al. 1998; Tayles 2007).
Thickening of the cranial vault of the skull and of the cortical bone of the femoral shaft was observed in two individuals from Khok Phanom Di (Tayles 1999).

Cribra orbitalia was more prevalent among subadults than adults from the northeast Thailand samples (Pietrusewsky 1974; Pietrusewsky and Toomay 2002; Domett 2004). In Ban Chiang, a statistically significant increase in the prevalence of cribra orbitalia over time in adult males was observed (Pietrusewsky and Toomay 2002). A decline in prevalence of cribra orbitalia was observed among subadults from the earlier period and the later period in Ban Chiang (Pietrusewsky and Toomay 2002). Porotic hyperostosis was observed in 14 individuals from Non Nok Tha (Pietrusewsky 1974).

Evidence of cribra orbitalia was found among the individuals from Man Bac in Vietnam (Oxenham et al. 2011). Males were more frequently affected than females, and no significant difference according to age was found (Oxenham et al. 2011).

The prevalence of cribra orbitalia among the individuals from Shi San Hang was relatively higher than other Southeast Asian samples (Pietrusewsky and Tsang 2003). A higher prevalence was seen among females than males, though the difference between the sexes was not statistically significant (Pietrusewsky and Tsang 2003).

**Interpretation of Health Using Skeletal Remains**

Inferring health from skeletal samples always comes with inherent biases and problems. Questions regarding the biases in representation of past populations using skeletal samples have been raised several times. The plasticity of bone during life needs to be taken into account when interpreting health from skeletal remains (Larsen 1997; Tayles 1999; Larsen 2000; Massaro and Rogers 2004; Buikstra and Beck 2006; Agarwal and Glencross 2011). Certain diseases do not leave visible marks on bone while some do depending on the stage or degree of severity of the disease. Definitions of health and disease as used in bioarchaeology are also rather different from the clinical sense (Goodman 1993; Larsen 1997; Larsen 2000). An overall generalization of the quality of life and presence of certain diseases within a population can be made by examining skeletal remains with the help of relevant archaeological and ethnographic data (Cohen 1994). This multidisciplinary approach helps overcome biases that are present from inferring health using only skeletal remains. Skeletal lesions are common signs of chronic illness while healed lesions can imply an individual’s survival from that particular disease. Interpretations on the prevalence and frequency of these
lesions are dependent on age and sex estimations, which is why a standardized method on estimating age and sex is important in bioarchaeological studies.

Not all diseases affect bone. Indeed, very few diseases leave discernible pathologies on dried bone (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodríguez-Martin 1998; Ortner 2003; Waldron 2009). Thus, examining only the skeletal remains gives us incomplete data on the health of past populations. However, these skeletal samples are the only direct representations of people from the past, thus any information from these individuals along with other archaeological information would be very valuable in understanding the health of past populations.

Wood et al (1992) discusses issues on the interpretation of health from skeletal remains, points out problems in sample representation and the inference of health based on disease observed from skeletal samples, which has been termed the osteological paradox. The paper discusses the paradox wherein the presence of pathological lesions in skeletal remains does not necessarily imply poor health and the absence of lesions does not equate to good health. Indeed, the presence of healed lesions indicates the capability of the individual to “fight back” and survive from the illness. While this is true, the mere presence of skeletal lesions suggests that the individual experienced some kind of stress which implies a poor quality of life. Looking at ethnographic and archaeological data also gives us a more holistic picture of life in the past and evidence from these sources so far suggests similar health status as those deduced from the examination of skeletal remains (Cohen 1994). In addition, alternative explanations and differential diagnosis can explain different scenarios which could have possibly happened. In this sense, health is not necessarily equated to the absence of disease but to the overall quality of life of the population.

Chapter Summary

This chapter has explored the archaeological and historical contexts of the skeletal samples from Southeast Asia and the Philippines. Bioarchaeological studies on health of past populations in Southeast Asia were reviewed and issues on the interpretation of health using skeletal remains were discussed. The prevalence of pathologies among individuals from comparable time periods in continental Southeast Asia was mainly similar. Overall, a decrease in the prevalence of oral pathologies, particularly caries, and an increase in the prevalence of skeletal pathologies over time was found. Similar trends were seen in sites from island Southeast Asia, although there was less skeletal pathologies among the individuals from island Southeast Asia compared to the samples from similar time periods in
continental Southeast Asia. However, very few individuals from island Southeast Asia have been examined which makes the comparison to samples from mainland Southeast Asia difficult.

The next chapter reviews the archaeological information on the skeletal samples from the Philippines and the methods used for the examination of these remains.
In this chapter, the background information regarding the samples used in this study is examined. The archaeological context of the samples is reviewed to provide a perspective of the environment within which these people lived. The methods used in the examination of these skeletal remains are also discussed.

The Samples

This section gives a brief background on the archaeological context of the individuals used in this study.

Ille Cave, Palawan (IV-1998-P)

Ille Cave is part of the Ille Rockshelter, a limestone karst tower standing at around 75 meters tall located in Dewil Valley in Northern Palawan (Paz and Ronquillo 2004; Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009). The site is approximately 14km from the El Nido town proper, the major hub of activity and the main city of Northern Palawan (Paz and Ronquillo 2004). The site is situated within the settlement of New Ibajay, where the population is composed mainly of late 20th century settlers originally from Aklan in northern Panay Island in the central Philippines (Paz and Ronquillo 2004). The tower is hollowed due to the formation of a cave network with three main mouths located at its base. The main entrance to the cave is via two large mouths which lead to a single chamber. These mouths were designated as the east and west mouths and the majority of the excavations were done in these areas as well as the area directly in front of the cave (Paz and Ronquillo 2004).
A large platform is found in front of the mouths along with an overhang that extends to approximately 10 meters (Paz and Ronquillo 2004). The karst tower is surrounded by thick vegetation though the platform had been cleared to provide a place for small gatherings. The whole area is surrounded by rain-fed rice fields and vegetable gardens maintained by the people living in New Ibajay. The site was first excavated in 1998 as part of an archaeological research project focusing on the island of Palawan by the National Museum of the Philippines (Paz and Ronquillo 2004). More recent excavations (from 2004 onwards) were made possible by the combined efforts of the National Museum of the Philippines and the Archaeological Studies Program of the University of the Philippines (UP-ASP) along with the contributions from local and foreign archaeologists to form the Palawan Island Palaeohistoric Research Project (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009; Paz et al. 2010). The site has been designated with the site code IV-1998-P by the Archaeology Division of the National Museum of the Philippines and all artifacts recovered from the site were labeled with this code.

Nine phases of cultural deposition had been initially identified based on excavations from the site, with the current phase, three burial phases and five habitation phases making up these cultural layers (Paz and Ronquillo 2004). However, more recent excavations and
analyses have condensed these phases into six cultural layers (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009; Paz et al. 2010). These sequences of cultural deposition were described from the latest to earliest and are discussed below.

The first occupation phase in the sequence is the 'current phase' which is dated to the late 19th century to the present (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009; Paz et al. 2010). This cultural layer is characterized by the presence of modern deposits and sediments (Paz and Ronquillo 2004; Paz and Ronquillo 2005-2006). This layer also includes scattered artifacts from lower layers due to disturbance from recent treasure hunting activities and human utilization of the site. The site had been used as a location for animal corrals during wet seasons in the 1990s, hang-out spot for young adults, and a religious center used for camping (Paz and Ronquillo 2004; Paz and Ronquillo 2005-2006).

The next occupation phase is labeled as the ‘intensified burial phase’ and dated to approximately 2000 years ago to around 200 years ago (19th century CE) (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009). This phase is distinguished by a high density of human burials from several time periods lying just above shell middens (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009). Burials from the upper layers of this phase had no grave goods or body ornaments unlike those from the deeper layers (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009). The burial pits were shallow, with depths of around 12cm, though the shallow depth is most likely due to post-1960s erosion dynamics because of the clearing of the forest at the platform (Paz and Ronquillo 2005-2006). Evidence of glass bead ornaments and possibly textile in deeper burials were found. A dog burial, as well as several badly preserved human burials associated with probable pig tusk necklace was retrieved (Paz and Ronquillo 2005-2006). Some tradeware ceramics not associated with burials were recovered and were dated to be from 10th – 14th centuries (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009). The most recent burials from this phase have an earliest possible date of 1761 based on a Spanish coin recovered alongside one of the burials (Paz et al. 2008). The former first burial phase falls under this layer (Paz and Ronquillo 2005-2006).

The ‘dominantly habitation phase’ is the third phase of the occupation sequence of the site (Paz and Ronquillo 2005-2006). This layer is dated to around 6000 to 2000 years ago (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009).
Features of domestic activity and one episode of shell midden formation were found in this layer (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007). This is followed by several sediment deposits of pottery remains, hearths, shell implements, and animal remains (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007). The first and youngest shell midden phase featuring shells of various types, some of which were worked, along with few animal bones was found in this phase (Paz and Ronquillo 2005-2006). The former burial phase 2 and 3 as well as the first habitation phase falls within this layer (Paz and Ronquillo 2005-2006).

The fourth phase in this sequence is the ‘dominantly pre-pottery habitation phase’ which is dated to around 6000 to 8000 years ago (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009). Shell middens with no associated pottery sherds, hearth formations, and two burials associated with an assemblage of shell artifacts were found from this layer (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007). The former habitation phase 2-D falls under this phase (Paz and Ronquillo 2005-2006).

The ‘habitation and cremation practice phase’ makes up the fifth phase of the cultural sequence from Ille Cave (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009). This phase is dated to be from around 8000 to 10000 years ago and is characterized by hearth features extending from 160-200cm as well as a cremation (Lewis et al. 2008) in an organic container at the upper level (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008). The former habitation phase 4 falls under this layer (Paz and Ronquillo 2005-2006).

The earliest and final phase is the ‘habitation phase’ dated to around 12000 BP and older (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009). This layer is identified by the presence of chert flakes and animal bones approximately 2 meters below the current surface (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007). The surface of this period has a steep slope ranging from 2 to 4.7 meters (Paz and Ronquillo 2005-2006). This layer also includes a series of compact sediments with no associated cultural, plant or animal remains (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007). The former habitation phase 5 is re-assigned under this phase (Paz and Ronquillo 2005-2006).

The chronology of the occupation phases at Ille Cave revealed that the site was first used for habitation due to the presence of shell middens and other evidence of human settlement such as hearth features and faunal remains. This human habitation phase spanned a lengthy time period and was accompanied by the presence of a few cremated animal and
human burials. A more intensive burial phase follows this habitation phase which was dated to as early as the late 17\textsuperscript{th} century based on the artifacts recovered on the same layer as some of the burials such as metal implements and a Spanish coin dated to the 17\textsuperscript{th} century (Paz and Ronquillo 2004; Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al. 2008; Paz et al. 2009; Paz et al. 2010).

Twenty-six individuals from this site have been examined for this thesis, all of which were stored at the osteology laboratory of the Archaeology Studies Program at the University of the Philippines. All of the individuals examined belonged to the ‘intensified burial phase’ of the site. Around fifty individuals have been recovered so far from the site, though most of these were stored in the Solheim Foundation base at El Nido and have not been examined. Most of the individuals that were stored at the osteology laboratory of the UP-ASP were from more recent excavations.

\textit{Sibaltan, Palawan (IV-2010-G1)}

Five individuals have been recovered from Sibaltan, a coastal site near Ille Cave in northern Palawan (Paz et al. 2010). The area of Sibaltan was reported to be heavily looted during the late 1970s and early 1980s, and various local accounts attest to the rich archaeology of the vicinity (Paz et al. 2009; Paz et al. 2010). Five trenches were excavated in the public elementary school within the area and three individuals have been transported to the UP-ASP for examination and storage (Paz et al. 2010). This site was chosen for study because local accounts indicated that this area was not included in the pot-hunting activities of treasure hunters during the 70s, which was confirmed by the stratigraphy recorded during the excavation (Paz et al. 2009; Paz et al. 2010). Accounts of school children uncovering burials with grave goods were also another factor as to why this area was chosen for excavation (Paz et al. 2009; Paz et al. 2010). The site was excavated last 2010 as part of the Palawan Island Palaeohistoric Research Project but has not been reopened since.

Three individuals from this site have been examined for this study, two of which were juveniles at around five to eight years old while one was a young adult at the time of death. All of these individuals were from Trench 1 (Paz et al. 2010). The individuals were estimated to be from around the same time period as the Spanish period burials from Ille Cave (Paz et al. 2010). Grave goods, mostly in the form of a variety of glass and stone beads and metal rings, were found with the remains (Paz et al. 2010), which were rarely found among the individuals from Ille Cave (Paz and Ronquillo 2005-2006; Paz and Ronquillo 2007; Paz et al.
2008; Paz et al. 2009). The site has been given the site code IV-2010-G1 by the National Museum of the Philippines.

**Bongabong, Mindoro (IV-2005-I)**

A church ruin site near the Anilao River within the municipality of Bongabong in Oriental Mindoro was excavated in 2005 as part of a course on fieldwork for archaeology graduate students of the University of the Philippines (Bangayan 2005; Basilia 2005; Campos 2005; Tiauzon 2005). The human remains recovered from the site were estimated to be from around the 16th century based on the floodplain feature found on the site (Bangayan 2005; Campos 2005; Ang et al. 2011). No evidence of earlier settlements had been recovered from the site, however, one burial, that of an adult male was found on a layer lower than the foundation of the church and is highly likely to be older than the church complex remains (Bangayan 2005; Campos 2005; Ang et al. 2011).

Three individuals from this site have been examined, all of which were stored in the osteology laboratory at the University of the Philippines. These individuals were found with associated grave goods such as earthenware pottery, blue and white porcelain and metal fragments. These Spanish period burials recovered were oriented towards the church altar, which suggests that these individuals had a strong belief in Christianity (Bangayan 2005; Basilia 2005; Campos 2005; Tiauzon 2005). An individual identified as an adult male was found in a deeper layer than the other burials (Bangayan 2005; Basilia 2005; Campos 2005). This adult male was buried with a rusted metal plow plate and a brain coral and is presumed to be older than the church complex artifacts and burials (Bangayan 2005; Basilia 2005; Campos 2005). This individual was not examined since the relative dating for this burial is rather problematic. The site code IV-2006-I was designated to the Bongabong site by the National Museum of the Philippines.

**Catanauan, Quezon Province (IV-2008-Q5)**

The site of Catanauan in Bondoc Peninsula had first been excavated in 2008 as part of a joint project among the National Museum of the Philippines, UP-ASP and the Australian National University (ANU). The Catanauan Archaeological and Heritage Project provided an opportunity for undergraduates studying Archaeology at ANU to learn basic fieldwork methods in Archaeology. Several undergraduate students in Anthropology and graduate students in Archaeology from the University of the Philippines also participated in the excavation. The project also contributed to the understanding of the settlement and
occupation of the Bondoc Peninsula region. The site is located near the coastal area at approximately 30 meters from the high tide point. The site has been designated with the code IV-2008-Q5 by the National Museum of the Philippines.

The initial excavation revealed Catanauan to be an extensive jar burial site, with numerous jar burials recovered from two trenches, one of which had evidence of looting by treasure hunters (Paz 2008). Both adults and subadults were buried using jars, and majority of the jar burials recovered were secondary burials. These jars were commonly covered with large coral slabs, which also served as grave markers (Paz 2008). An extensive shell midden was also exposed and recorded within the site (Paz 2008). Grave goods in the form of metal implements, glass beads and shell discs were included in some of the jar burials, which indicated that these burials were from the Metal period (Paz 2008). One jar burial was marked by the presence of a large *Tridacna* species shell and few large conical shells (Paz 2008). Excavations on succeeding seasons have revealed the presence of extended burials within what was previously deemed as a culturally sterile layer (Paz 2011). However, these burials had not been excavated until the latest field season due to time constraints and were thus not examined. These burials were presumably older than the jar burials found on the upper layers. Relative dating of the burials based on associated artifacts has revealed that these extended burials were at least 1000 years old (Paz 2011).

Five phases of cultural deposition have been recorded from the site (Paz 2008). These phases were described from the earliest to the latest. The first phase, relatively dated at approximately 4000 years ago, is characterized by the presence of humans manufacturing and using well-fired reddish pottery and might be associated with the early pottery cultures in the Philippines (Paz 2008). The second phase is marked by the settlement of people practicing jar burials (Paz 2008). This phase has been divided into three different time periods based on the relative stratigraphic position of similar artifacts (Paz 2008). The third phase is described as “most likely a later practice of jar burial, but still associated with the same people staying in the same landscape at an early time” (Paz 2008, p.24) and includes the jar burials found on the upper layers of trench four and six. The fourth phase is characterized as a period of cultural hiatus for the site due to the absence of cultural materials on the layers above the jar burials (Paz 2008). The fifth and final phase is distinguished by the presence of 20th century human activity and signs of modern debris and mechanical cultivation (Paz 2008).

Eighteen individuals have been examined from the site, all of which were stored in the osteology laboratory of the UP-ASP. A few infant burials had been recovered from the site
Jar burial complexes found in the neighboring region of Bicol bear several features which are rather akin to those found in Catanauan. Several adult and juvenile jar burials were recovered from the sites Tigkiw na Saday, Barangay Casay Casiguran Town, San Juan in Bacon and Binisitahan in Boton, Casiguran (Dizon 1979a; Dizon 1979b; Dizon 1979c). All of these sites except for the Binisitahan site were located inland and all were open-air sites. The forms of the jars as well as the artifacts found within these jars were very

(Paz 2008), though all the individuals examined were adults as the infant remains seem to be missing.

Jar Burial Tradition in the Philippines

Jar burials were a common practice not just among pre-Hispanic Filipinos but also throughout the rest of pre-colonial Southeast Asia. This tradition persisted in the Philippines even after the arrival of Europeans within the region (Solheim 1961; Dizon 2000). Different varieties of jars used for burials have been found throughout the archipelago, from nondescript earthenware jars with stone or coral lids found in Southern Luzon to the more elaborately decorated jars found in Palawan and Mindanao. The origin of this practice is currently unknown, though arguments for a single cultural source (Beyer 1947) and multiple cultural sources (Solheim 1961; Fox 1970) have been proposed. Jar burials recovered from archaeological sites throughout the Philippines were both primary and secondary. Primary jar burials refer to those where the individuals were buried in jars immediately after death while secondary jar burials are those where the individuals were first buried elsewhere after death to allow for the decomposition of the flesh and were then exhumed and placed in jars after the bodies have decomposed (Pearson 1999; Andrews and Bello 2006; Duday 2009).

The jar burials excavated in Catanauan bear several similarities to those previously excavated elsewhere in Southern Luzon. The jar burials from the coastal sites of Recud and Tumagudtud in San Narciso, Tayabas, Quezon yielded several earthenware jars with grooved stone covers similar to those found in Catanauan (Solheim 1951). Some of these burials included fragments of human remains with articulated joints, suggesting that these burials were primary (Solheim 1951). Grave goods found amongst the burials include paste beads and shell artifacts as well as iron, stone and bone tools (Solheim 1951). Extended burials were also recovered from Tumagudtud, all of which were inferred to belong to the same time period as the jar burials from the area based on associated artifacts and stratigraphy (Solheim 1951).

The jar burial complexes found in the neighboring region of Bicol bear several features which are rather akin to those found in Catanauan. Several adult and juvenile jar burials were recovered from the sites Tigkiw na Saday, Barangay Casay Casiguran Town, San Juan in Bacon and Binisitahan in Boton, Casiguran (Dizon 1979a; Dizon 1979b; Dizon 1979c). All of these sites except for the Binisitahan site were located inland and all were open-air sites. The forms of the jars as well as the artifacts found within these jars were very
similar to those found in Catanauan (Dizon 1979a; Dizon 1979b; Dizon 1979c; Paz 2008). However, no skeletal material had been found from these sites due to the high acidity of the soil which resulted in the poor preservation of human remains (Dizon 1979c; Dizon 1979a; Dizon 1979b). Relative dating of these sites based on the artifacts recovered puts these sites within the developed metal period which dates to approximately 700 BCE to 1000 CE (Dizon 1979a; Dizon 1979b; Dizon 1979c; Paz 2008). Plain earthenware jars containing poorly preserved skeletal remains were also found in Bagatao Island in Magallanes, Sorsogon which is also within the Bicol region (Cuevas 1992). These jar burials were reported to be primary and were hypothesized to be related to the inland jar burial sites within the Bicol region (Cuevas 1992).

Another jar burial site which bears some similarities to Catanauan is in Makabog in the small island of Masbate also within the Bicol region. A grooved stone cover for burial jars was also recovered from the site, and the burial jars retrieved were very similar in form to those found in the San Narciso site (Solheim 1954). These similarities give support to the hypothesis (Dizon 1979b; Dizon 1979c; Dizon 1979a; Paz 2008) that the Southern Luzon region had been inhabited by people from the same cultural group or people who have had very close contact with each other (Paz 2008).

Jar burials were also found in Batanes, Palawan and South Cotabato in Mindanao (Solheim 1961; Fox 1970; Dizon 1996; Dizon 2000; Barretto-Tesoro 2003). However, these jars are rather different from the ones found in the Quezon and Bicol regions. The burial jars in Batanes were also mostly plain, although another upside-down jar were usually used as covers instead of coral slabs (Solheim 1961; Dizon 2000). The secondary burial jars found in Palawan and South Cotabato were elaborately decorated unlike the plain jars from Batanes and Southern Luzon (Fox 1970; Dizon 1996). It is possible that these jars were from a different jar burial culture than those seen in other parts of the Philippines (Solheim 1961; Fox 1970).
A summary of the sites where skeletal remains have been examined is presented in Table 3.1 along with the approximate dates of the burials and the number of individuals.

Table 3.1. Archaeological sites in the Philippines where skeletal remains were examined for this study.

<table>
<thead>
<tr>
<th>Site</th>
<th>Region</th>
<th>Time Period</th>
<th>Individuals used in this study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ille Cave</td>
<td>Northern Palawan</td>
<td>17th - 18th century</td>
<td>26</td>
</tr>
<tr>
<td>Sibaltan</td>
<td>Northern Palawan</td>
<td>17th - 18th century</td>
<td>3</td>
</tr>
<tr>
<td>Bongabong</td>
<td>Oriental Mindoro</td>
<td>16th century</td>
<td>3</td>
</tr>
<tr>
<td>Catanauan</td>
<td>Southern Luzon</td>
<td>1000 years ago</td>
<td>18</td>
</tr>
</tbody>
</table>
Methods

This section reviews the methods used in the examination of the skeletal remains. Techniques on aging and sexing are discussed as well as the recording of indicators of disease and pathology found on the remains.

Aging

Estimating age in skeletal remains entails the examination of minute changes in certain areas of the bone for features that are correlated with age. For adults, recording the changes on the surface of the pubic symphysis and auricular surfaces of the pelvic bones are well-known methods of age estimation (Lovejoy et al. 1985b; Buikstra et al. 1994; Suchey and Katz 1998). The presence of billowing on the surfaces of the pubic symphysis and auricular surfaces of the ilium indicate that the individual is young while the loss of billowing, porosity and erosion of the joint surface are usually observed among older adults (Lovejoy et al. 1985b; Katz and Suchey 1989; Suchey and Katz 1998). The changes that occur on the pubic symphysis and auricular surfaces were divided into different phases which correspond to a specific age group. Other methods include the observation of changes in the sternal ends
of the ribs, the fusion of cranial sutures, dental wear and joint degeneration (Lovejoy 1985; Meindl and Lovejoy 1985; Iscan et al. 1989; Iscan 1991; Roberts 2009). For the sternal ends of the ribs, billowing is also an indicator that the individual is young while coarseness and irregularity of the rim suggests that the individual is older (Iscan et al. 1989; Iscan 1991). Fusion of cranial sutures indicates that an individual is older than those with unfused sutures, though the age of closure of cranial sutures is highly varied (Meindl and Lovejoy 1985). More severe dental wear and joint degeneration also suggest that an individual is older but the severity of wear and degeneration can vary in different populations (Lovejoy 1985; Resnick 1995).

Figure 3.4. Phases of pubic symphyseal changes based on the Todd method (White and Folkens 2005).

Figure 3.5. Phases of pubic symphyseal changes based on the Suchey-Brooks method (Katz and Suchey 1989; Suchey and Katz 1998).
Figure 3.6. Phases in auricular surface changes according to age (Lovejoy et al. 1985b; White and Folkens 2005).

Figure 3.7. Phases of sternal rib end changes (Iscan 1991).
For subadults, recording tooth eruption and measuring diaphyseal lengths of long bones are common methods of age estimation (Scheuer and Black 2004; White and Folkens 2005). The formation and eruption of teeth have been known to be closely correlated with age and is less affected by nutritional and environmental factors compared with the diaphyseal lengths of long bones (Scheuer and Black 2004). Fusion of various skeletal elements such as epiphyseal fusion of long bones (the fusion of the extremities of long bones to the diaphysis or shaft), the fusion of neural arches to vertebral bodies and the fusion of the pelvic bones are also useful indicators of age for subadults (Scheuer and Black 2004).

Figure 3.8. Dental eruption chart taken from White (2005) adapted from Ubelaker (1989).
A multivariate approach was used in the estimation of age for all skeletal remains (Lovejoy et al. 1985a). This is due to the nature of the sample, where several, if not all, individuals were represented by incomplete skeletal elements. For adults, aging was assessed based on changes observed in the pubic symphysis and the auricular surfaces of the pelvic bones, the fusion of cranial sutures and the changes in the sternal ends of ribs (Lovejoy et al. 1985b; Meindl and Lovejoy 1985; Buikstra et al. 1994; Suchey and Katz 1998). Tooth wear and joint degeneration were also taken into account in assessing age as these features have been found to be highly correlated with age (Scott 1979; Lovejoy 1985; Resnick 1995; Rogers and Waldron 1995). For infants and subadults, tooth formation & eruption and diaphyseal lengths were used in estimating age as well as fusion of long bone epiphyses and vertebral elements, with preference given to dentition (Buikstra et al. 1994; Scheuer and Black 2004; White and Folkens 2005).

All individuals were then assigned to a relative age group as the assessment of absolute age was not attempted. This is because the application of methods developed for a different set of population is problematic and causes discrepancies among different individuals since variation in the presence of age indicators occur within and in between populations (Katz and Suchey 1989; Iscan 1991; Buikstra et al. 1994). Even the estimation of age through the application of aging methods for skeletal remains within the same population does not produce particularly accurate results due to variations in skeletal changes among different individuals (Katz and Suchey 1989; Iscan 1991; Buikstra et al. 1994). When working with skeletal remains, evidence is already incomplete due to the loss of soft tissue which would yield a more definitive result. To err on the side of caution, individuals were aged relative to each other and assigned to different age groups as to where they most likely belong. Six different age categories were used for comparing individuals according to age. These categories included children (individuals over a year old to the age of twelve), adolescents (individuals aged from thirteen to early twenties), young adults (individuals from mid-twenties to early thirties), mid-adults (individuals from mid-thirties to fifties), old adults (individuals aged fifty and over) and unknown adults (adult individuals of unknown age). The age category for infants (individuals below a year old) was not included as no individuals from this age group were examined.

Individuals assigned to the children category included those with unfused neural arches and long bone epiphyses as well as those belonging to this age category based on tooth calcification and eruption (Buikstra et al. 1994; Scheuer and Black 2004). Individuals included in the adolescent age group were those with relatively longer diaphyseal
measurements, fusion of cranial sutures and vertebral elements as well as incomplete fusion of long bone epiphyses and full eruption of permanent teeth (Buikstra et al. 1994; White and Folkens 2005). Individuals with fused cranial sutures, vertebral elements and long bone epiphyses with pubic symphyses in phases 1 to 2 of the Suchey-Brooks method and phases II to V of the Todd method were classified as young adults (Buikstra et al. 1994; Suchey and Katz 1998; White and Folkens 2005). These individuals were also recorded to be within the phase 1 to 3 for the changes in auricular surfaces of the ilium and phases 2 to 4 for the changes in sternal rib ends (Lovejoy et al. 1985b; Iscan 1991). Individuals with pubic symphyses that belong to the phases 3 to 4 using the Suchey-Brooks method and phases VI to VIII using the Todd method were categorized as mid-adults (Suchey and Katz 1998; White and Folkens 2005; Buikstra and Beck 2006). These individuals also exhibited auricular surfaces belonging to phases 4 to 6 and sternal rib ends from phases 5 to 6 (Lovejoy et al. 1985b; Iscan 1991).

**Sexing**

Estimation of sex using skeletal remains is possible through the examination of certain skeletal elements for features indicative of the individual’s sex. The most common parts of the skeleton used for sexing are the pelvis and the skull since these skeletal elements exhibit the most extreme sexual dimorphism to aid in the estimation of sex (Phenice 1967; Phenice 1969; Sutherland and Suchey 1991; Buikstra et al. 1994; France 1998; Graw et al. 1999; Cox and Mays 2000; Gulekon and Turgut 2003; White and Folkens 2005). Overall robusticity of the skeleton can also help in estimating sex since generally, males have larger muscle attachments therefore have more robust skeletons than females (Weiss 2003). However, variations in robusticity among populations do occur due to different activity patterns and biological differences and what may be robust in one population can be rather gracile in another (Niinimaki 2011; Weiss et al. 2012).

On the pelvic bone, features such as the greater sciatic notch, subpubic angle, width of the pubic bone, presence of the ventral arc, subpubic concavity, sharpness of the ischio-pubic ramus ridge, shape of the obturator foramen, iliac flaring, shape of the pelvic inlet, concavity of the sacrum and presence of parturition scars are used for assessing sex (Phenice 1967; Phenice 1969; Sutherland and Suchey 1991; France 1998; White and Folkens 2005). The greater sciatic notch is usually wider among females and narrower among males. The angle formed below the pubic symphyseal joint is the subpubic angle and is generally bigger among females. The ventral arc is only present in female pubic bones while an elevated ridge may be
present among males. The dorsal surface of the ischio-pubic ramus below the pubic bone is generally concave in females and straight in males. The medial aspect of the ischio-pubic ramus just below the pubic symphysis is sharp among females and flat among males. Among females, the obturator foramen is more triangular while it is more oval among males. Females have a more extremely flared ilium, wider pelvic inlet and flatter sacrum than males. Parturition scars on the dorsal surface of the pubic bone and below the auricular surface of the ilium can also be seen in females who have given birth (Putschar 1976; Holt 1978; Kelley 1979), though these scars have also been observed among men and may be due to several other factors such as obesity, pelvic instability and occupation-related activities (Harris and Murray 1974; Andersen 1988; Cox 2000; White 2005; Ubelaker and De La Paz 2012).

Figure 3.9. Variations in width of the greater sciatic notch of the pelvic bone (White and Folkens 2005). The notch marked as 1 is characteristic of a female sciatic notch while 5 is typical among males.

Figure 3.10. The ventral arc and subpubic concavity of the pelvic bone of a male and a female (White and Folkens 2005).
Skeletal features in the skull that are used for determining sex include the nuchal crest, mastoid process, supraorbital margin, supraorbital ridge and the mental eminence of the mandible (Buikstra et al. 1994; Graw et al. 1999; Gulekon and Turgut 2003; White and Folkens 2005). These features are usually more prominent among males, though the degree of prominence may vary in between populations (Buikstra et al. 1994; White and Folkens 2005).
Figure 3.1. Sexually dimorphic features of the skull scaled from 1 to 5 (White and Folkens 2005). 1 represents a more female characteristic while 5 is more typical of males.

Like the estimation of age, a multivariate approach was also used in assessing sex. All available data from each individual were recorded and used to estimate sex. Pelvic features exhibiting sexual dimorphism were recorded for sex assessment. Several sexually dimorphic cranial features were also recorded. The presence of these features were recorded using a nominal scale of one to five, with one exhibiting a more typically masculine and five a more typically feminine expression of that particular feature. All individuals were categorized into three groups according to sex: male, female and unknown. Individuals that were assigned to the unknown category were either children that were unable to be sexed or adults whose skeletal elements that are commonly used for sexing were either missing or heavily fragmented. Subadults were unable to be sexed as the skeletal elements exhibiting sexually dimorphic features were still developing during the time of death, thus the methods commonly used in assessing sex for adults would be inapplicable (Sutherland and Suchey 1991; Buikstra et al. 1994; France 1998).

Antemortem and Postmortem Damage

Extreme caution was taken in assessing skeletal and oral pathologies so as not to confuse these lesions with those that occurred due to postmortem damage. Bioturbation and
other human activities such as mechanical plowing of the sites where the remains examined were excavated from have contributed to the presence of postmortem damage on the remains (Paz 2004; Paz 2008; Paz et al. 2010). The transport of these remains would have also rendered some damage on the bones which can be differentiated from those that occurred during the individual’s life. The difference in the appearance of trabeculae in damaged bones is useful in assessing postmortem damage from antemortem injuries. Evidence of remodelling within the trabeculae of bone damaged during a person’s life should be present (Ortner and Putschar 1985; Aufderheide and Rodriguez-Martin 1998; Mays 1998; Sauer 1998; Ortner 2003). The edges of the lesions that occurred during antemortem should be more rounded and smoother due to remodelling while postmortem lesions should have sharper edges (Gentry Steele and Bramblett 1988; Roberts and Manchester 1995; Mays 1998; Sauer 1998; Ragsdale and Lehmer 2012). These differences are due to the nature of bone remodelling as a response to injury or other pathology during life. Bone repair after trauma undergoes phases of healing which includes the formation and destruction of bone at an accelerated rate after injury (Sauer 1998). The presence of beveling, bone peeling, and striations in skeletal lesions are indicators of perimortem damage (Sauer 1998). Perimortem damage refers to the injuries on bone which occurred shortly before death (Sauer 1998). A difference in color between the damaged area and surrounding bone can also indicate whether a lesion occurred during antemortem or postmortem (Mays 1998; Sauer 1998; Roberts 2009). Since postmortem lesions can occur when the bones were dry, a differentiation in color on the damaged area would be more apparent due to the different taphonomic processes involved while the bone was still intact (Mays 1998; Sauer 1998; Roberts 2009). However, it is not always possible to differentiate perimortem from postmortem damage due to the diverse array of taphonomic factors that affect bone preservation (Mays 1998; Sauer 1998; Cox and Mays 2000; Waldron 2001; Waldron 2009).

Bone preservation was assessed by looking at the amount of postmortem damage in each skeletal element since postmortem damage affects the observable skeletal pathologies from each individual. Each bone was examined for the amount of postmortem damage and scaled from 1 to 3. A scale of 1 means that the bone had less than 25% of damage, 2 means that the bone had 25% to 75% of damage and 3 means that more than 75% of the bone had postmortem damage. A description of the location of the damage was also recorded.
Skeletal Pathologies

Living bone is constantly remodelled through the activities of osteoclasts, the cells that remove bone, and osteoblasts, the cells responsible for bone formation (Gentry Steele and Bramblett 1988; Larsen 1997; Lovell 2000; Waldron 2001; Waldron 2009; Ortner 2012). Bone can be remodelled in response to some form of stress, to repair bone defects or to release calcium for other metabolic processes (Lovell 2000; Waldron 2001; Waldron 2009; Ragsdale and Lehmer 2012). Skeletal pathologies are formed when there is an imbalance of osteoclasts and osteoblasts on the bone (Lovell 2000; Waldron 2001; Waldron 2009; Ortner 2012). Thus, there are two types of skeletal lesions resulting from this imbalance: osteoblastic or proliferative lesions are bony formations due to overproduction of osteoblasts and osteolytic or resorptive lesions which are due to excessive osteoclasts in bone (Lovell 2000; Waldron 2001; Waldron 2009; Ortner 2012). These lesions may be active or healed. Active lesions refer to those which indicate active disease at the time of death and are usually sharp-edged and irregularly-shaped (Lovell 2000; Waldron 2001; Waldron 2009; Ortner 2012). Healed lesions, which reflect recovery from a disease, are those that had evidence of remodelling and are thus smoother-edged than active lesions (Lovell 2000; Waldron 2001; Waldron 2009; Ortner 2012).

Figure 3.14. An example of an osteoblastic (left) lesion from individual 2 from Bongabong and osteolytic (right) lesion from individual 3 from Ille Cave. Photos taken by author.
Skeletal pathologies were recorded using guidelines from several specialists on skeletal paleopathology (Steinbock 1976; Rothschild and Martin 1993; Buikstra et al. 1994; Roberts and Manchester 1995; Rogers and Waldron 1995; Mays 1998; Cox and Mays 2000; Buckley and Tayles 2003; Ortner 2003; Mays 2008; Waldron 2009). Skeletal lesions and other unusual features were recorded according to the region where these lesions were found: cranial, appendicular (upper and lower) and axial. The location of the lesions on the specific bone was also recorded. These lesions were assessed to be either osteoblastic or osteolytic or a combination of the two. The lesions were also recorded as either active or remodelled during the time of death. A description of the appearance and size of the lesions was also noted. The percentage of bone affected by these lesions was recorded using a nominal scale of 1 to 3 where one means less than 25% of the bone was affected, two means 25% to 75% of the bone was affected and three means more than 75% of the bone was affected (Buikstra et al. 1994). For the joint pathologies, the degree of severity of the joint lesions was scored from one to four where one means only pitting was observed on the joint, two means lipping was observed, three means a combination of pitting and lipping were observed, and four means eburnation was present on the joint (Buikstra et al. 1994; Rogers 1995; Waldron 2009; Waldron 2012). Lipping and porosity were scored on a scale of 1 to 3 according to severity as shown in Figures 3.15 and 3.16 (Buikstra et al. 1994). Apart from individuals with eburnation, only those with both lipping and porosity were diagnosed with degenerative joint disease since specialists had advised that if there is no eburnation, at least two criteria must be present to confirm the diagnosis (Resnick 1995; Rogers and Waldron 1995; Waldron 2001; Waldron 2009). All proliferative and resorptive lesions on and around joint surfaces were recorded and scored from 1 to 3 according to severity and percentage of joint surface affected (Buikstra et al. 1994). These lesions and pathologies were photographed. The recording forms used were similar to those used in recording lesions and other features from individuals from Thailand and the Pacific used in previous studies. Possible aetiologies of the lesions were then identified in a differential diagnosis (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Rodriguez-Martin 2006; Waldron 2009; Ortner 2012). The skeletal pathologies discussed in this section are those from diseases that one might expect to find during the pre-colonial and early colonial period in the Philippines and other parts of Southeast Asia based on historical studies (Bamber 1993; Newson 1998; Newson 1999; Newson 2006).
Figure 3.15. Scale for the degree of porosity on articular surfaces. The left picture shows tiny pinprick holes while the middle one shows the coalescing of the tiny holes to form bigger porosities. The picture on the right shows a more severe form of porosity with medium to large holes on the surface of the vertebral bodies. Vertebrae on photos are from individual 2247 from Ille Cave. Photos taken by author.

Figure 3.16. Scale for the degree of lipping around the joint. The left picture shows minimal lipping on the right side as indicated by the arrows. The middle picture shows moderate lipping on the lateral sides of the vertebral body while the picture on the right shows severe osteophyte formation on the right side of the vertebral body. Vertebrae on photos are from individual 2 from Bongabong. Photos taken by author.

**Joint Diseases**

Joints refer to the articulation between different bones of the body and include the articular ends of the bones as well as soft tissue surrounding the articulation (Gentry Steele 1988; Resnick 1995; Rogers and Waldron 1995; Palastanga et al. 2002; Snell 2007). There are three different types of joints according to their structure: fibrous, cartilaginous and
synovial (Resnick 1995; Snell 2007). Fibrous joints refer to those connected by dense connective tissue made up mainly of collagen and are immovable (Gentry Steele and Bramblett 1988; Resnick 1995; Snell 2007). Cartilaginous joints are joints connected by cartilage and allow for some movement but are not as mobile as synovial joints (Gentry Steele and Bramblett 1988; Resnick 1995; Snell 2007). Synovial joints are free-moving joints bound together by a fibrous capsule (Gentry Steele and Bramblett 1988; Resnick 1995; Snell 2007). Joint pathologies are commonly found among cartilaginous and synovial joints since these joints allow movement and are therefore more exposed to stress (Resnick 1995; Rogers and Waldron 1995; Waldron 2009). Defects in the structure or cartilage of the joint result in bone deposition and resorption as compensation for the damage which forms the joint pathologies observed on dry bone (Resnick 1995; Rogers and Waldron 1995; Waldron 2009). The type and manner of lesion distribution on the joints helps in clarifying which particular joint disease has caused these bony changes (Resnick 1995; Rogers and Waldron 1995). The joint diseases that have been observed among skeletal samples from past populations are reviewed below.

**Degenerative Joint Disease (DJD)/Osteoarthritis**

Degenerative joint disease (DJD) is the most common form of joint disease seen throughout past and present populations and is characterized by the degeneration of cartilage at joints (Rogers and Waldron 1995; Mays 1998; Cox and Mays 2000; Waldron 2001; Waldron 2009). DJD is diagnosed on joints exhibiting porosity on and lipping or osteophyte formation around the articular surfaces of the joints (Steinbock 1976; Rogers et al. 1987; Rogers and Waldron 1989; Mann and Murphy 1990; Resnick 1995; Rogers and Waldron 1995; Aufderheide and Rodriguez-Martin 1998; Mays 1998; Waldron 2001; Ortner 2003; Waldron 2009). These lesions are formed to compensate for the defects in articular cartilage due to excessive usage or normal wear and tear (Brandt and Fife 1986; Lukoschek et al. 1988; Walker et al. 1988; Alexander 1989; Alexander 1990; Resnick 1995; Rogers and Waldron 1995; Waldron 2001; Weiss and Jurmain 2007; Waldron 2009; Molnar et al. 2011). The presence of eburnation, a polished area on the joint surface formed by bare bone moving over adjacent surfaces, indicates joint inflammation which makes osteoarthritis a likely aetiology (Rogers et al. 1987; Rogers and Waldron 1989; Resnick 1995; Weiss and Jurmain 2007; Waldron 2009). Osteoarthritis is frequently interchanged with degenerative joint disease in the medical and bioarchaeological literature (Resnick 1995; Rogers and Waldron 1995). However other sources classify osteoarthritis as a form of arthritis characterized by the
inflammation of the joints which may not be degenerative in nature, whereas DJD refers to the general degradation of the joints (Resnick 1995; Jurmain 1999; Waldron 2001). There are multiple factors that contribute to the presence and prevalence of DJD such as genetics, environment, age and sex, activity, metabolic status and obesity (Kellgren et al. 1963; Saville and Dickson 1968; Hernborg and Nilsson 1973; Lee et al. 1974; Acheson and Collart 1975; Brandt and Fife 1986; Croft et al. 1992; Kujala et al. 1994; Coggon et al. 1998; Cooper et al. 1998; Lau et al. 2000; Jensen 2008; Waldron 2012).

![Figure 3.17. DJD of the cervical vertebrae (left) and eburnation of the lateral condyle of the femur (right). The photo on the left is the 3rd to 7th cervical vertebrae of individual 2 from Bongabong taken by the author. The photo of the eburnation on the right is from the Museum of London website (Henderson 2009).](image)

**Intervertebral Disc Disease**

Intervertebral disc disease is characterized by both the pitting of the superior and inferior surfaces of the vertebral bodies and marginal osteophytosis (Resnick 1995; Ortner 2003; Waldron 2009). This occurs as a result of the bulging of the nucleus pulposus, the central part of the intervertebral disc, and the collapsing of the annulus fibrosus, the outer fibrous part of the intervertebral disc (Guiot and Fessler 2000; Adams and Roughley 2006; Roberts et al. 2006). The degeneration of the intervertebral discs is due to excessive stress on the vertebrae and has been associated with aging (Buckwalter 1995; Adams et al. 1996a; Adams et al. 1996b; Adams and Dolan 1997; Boos et al. 2002). In some cases, osteophytes can encroach on to the intervertebral foramen which may cause neurological complications (Resnick 1995; Rogers and Waldron 1995; Waldron 2009).
Schmorl’s nodes

Schmorl’s nodes are caused by the herniation of the annulus fibrosus on the vertebral bodies (Resnick and Niwayama 1978; Resnick 1995; Rogers and Waldron 1995; Peng et al. 2003; Waldron 2009). Schmorl’s nodes are commonly found on the lower thoracic and lumbar regions of the vertebrae and usually affect older people and elite athletes (Steinbock 1976; Sward 1992; Aufderheide and Rodriguez-Martin 1998; Pfirrmann and Resnick 2000; Ortner 2003; Waldron 2009). They are characterized by the presence of sclerotic lesions (lytic lesions with evidence of remodelling on the margins) on vertebral bodies (Steinbock 1976; Resnick and Niwayama 1978; Pfirrmann and Resnick 2000; Peng et al. 2003; Waldron 2009). The presence of Schmorl’s nodes on the anterior part of vertebral bodies accompanied with kyphosis and osteophytosis is indicative of Scheuermann’s disease, a form of juvenile osteochondropathy (disease of the bone and cartilage) of the spine (Aufdermaur 1981; Bradford 1981; Rogers and Waldron 1995; Ali et al. 1999; Ortner 2003; Waldron 2009).
Rheumatoid Arthritis

Rheumatoid arthritis is a systemic inflammatory disorder of the synovial membrane which results in the formation of the pannus (Copeman 1948; Capell et al. 1983; Resnick 1995; Rogers and Waldron 1995; Waldron 2009). Pannus is a fibrovascular tissue which destroys articular cartilage and leads to the formation of resorptive lesions on articular surfaces (Resnick 1995; Rogers and Waldron 1995; Scott et al. 2000; Green and Deodhar 2001; Kim and Hilibrand 2005; Waldron 2009). A combination of genetic, environmental and personal factors contributes to the development of the disease (Dresner 1957; Fudenber.Hh and Franklin 1965; Rogers and Waldron 1995; Howe 1998; Urbina-Joiro et al. 1998; Waldron 2009; Waldron 2012).

Ankylosis of joints accompanied with destruction of cortical bone particularly on the hands and feet is indicative of rheumatoid arthritis (Ortner and Putschar 1985; Green and Deodhar 2001; Waldron 2009; Waldron 2012). These lesions commonly occur symmetrically, and usually affect the extremities of the limbs with no spinal fusion (Green and Deodhar 2001; Ortner 2003; Waldron 2009; Waldron 2012). Joints affected by rheumatoid arthritis exhibit minimal new bone formation and the sparing of sacroiliac joints are common (Resnick 1995; Rogers and Waldron 1995; Scott et al. 2000; Green and Deodhar 2001; Waldron 2009; Waldron 2012). Osteoporosis may be present on the affected joints (Waldron 2009; Waldron 2012).
Sero-negative Arthropathies

Sero-negative arthropathies refer to joint diseases with a negative rheumatoid factor (Huskisson and Hart 1987; Weinstein and Kattan 1988; Resnick 1995; Rogers 1995; Waldron 2001; Waldron 2009; Waldron 2012). The rheumatoid factor is an antibody directed against an organism’s own tissues which contributed to rheumatoid arthritis (Copeman 1948; Capell et al. 1983). Joint diseases classified as sero-negative arthropathies include erosive osteoarthritis and the sero-negative spondylarthropathies.

Erosive Osteoarthritis

Erosive osteoarthritis is a severe form of interphalangeal osteoarthritis characterized by the presence of erosive lesions on the articular surface of joints and not on the marginal area of articular surfaces (Crain 1961; Peter et al. 1966; Rogers and Waldron 1995; Waldron 2009; Waldron 2012). The aetiology of erosive osteoarthritis is unclear though some evidence suggests genetic factors contribute to the pathogenesis of the disease (Stern et al. 2003; Bijsterbosch et al. 2011). The eburnation of hand joints with asymmetrical erosions of articular surfaces is characteristic of erosive osteoarthritis (Crain 1961; Peter et al. 1966; Ortner 2003; Punzi et al. 2004; Waldron 2009). This disease is usually found on the interphalangeal joints and is more common among women than men (Crain 1961; Peter et al. 1966; Ortner 2003; Punzi et al. 2004; Waldron 2009). ‘Gull wing’ and ‘saw tooth’ marks on affected joints may be seen on radiographs of the skeletal elements affected with this disease (Crain 1961; Peter et al. 1966; Punzi et al. 2004; Waldron 2009). Erosive osteoarthritis is
rarely seen in skeletal populations; only a single paleopathological case has been reported so far (Rogers et al. 1991).

Figure 3.21. Radiograph of an individual with erosive osteoarthritis on the right hand. The gull wing and saw tooth marks characteristic of erosive OA are indicated by the arrows. Photo from www.discoverymedicine.com (Anandarajah 2010).

Sero-negative Spondylarthropathies

Sero-negative spondylarthropathies are sero-negative arthropathies involving the vertebral column (Huskisson and Hart 1987; Weinstein and Kattan 1988; Resnick 1995; Rogers 1995; Waldron 2009). These diseases have common morphological, immunological and genetic features (Huskisson and Hart 1987; Weinstein and Kattan 1988; Resnick 1995; Rogers 1995; Waldron 2009). Psoriatic arthropathy, Reactive arthropathy and ankylosing spondylitis are sero-negative spondylarthropathies which includes some bony reaction and are thus observable among skeletal samples.
Psoriatic Arthropathy

Psoriasis is an autoimmune skin condition with a genetic pathogenesis (Roenigk and Maibach 1991; Kamisa 1994). Not all individuals with psoriasis develop psoriatic arthropathies, though a clear correlation between the two has been established (Fearon and Veale 2001; Veale and FitzGerald 2002a; Veale and FitzGerald 2002b). Joint pathologies associated with psoriasis are usually manifested on the interphalangeal hand joints, the spine and the sacroiliac joints (Veale and Fitzgerald 1992; Resnick 1995; Waldron 2009; Waldron 2012). Psoriatic arthropathy is characterized by the erosion of the distal interphalangeal joints (DIP) and paravertebral bridging (Veale and Fitzgerald 1992; Veale and FitzGerald 2002a; Ortner 2003; Waldron 2009). These lesions may be asymmetric or symmetric and features the appearance of the ‘cup and pencil’ sign on radiographs (Veale and FitzGerald 2002a; Ortner 2003; Waldron 2009).

Reactive Arthropathy (Reiter’s Syndrome)

Reactive arthropathy has been described as a complication from a gastro-intestinal illness such as dysentery accompanied with urethritis and conjunctivitis (Resnick 1995; Rogers 1995; Toivanen 2004; Hannu et al. 2006; Waldron 2009; Hannu 2011). This arthropathy is triggered by the infection of the intestinal region or of the reproductive area (Resnick 1995; Rogers 1995; Toivanen 2004; Hannu et al. 2006; Waldron 2009; Hannu 2011). Skeletal lesions due to reactive arthropathy are usually asymmetric and commonly occur in the lower limbs (Resnick 1995; Rogers 1995; Toivanen 2004; Waldron 2009; Hannu 2011). This disease is also marked by an asymmetric fusion of the sacroiliac joints, the presence of paravertebral bridging and an asymmetric erosion of small foot joints (Resnick 1995; Rogers 1995; Toivanen 2004; Waldron 2009; Hannu 2011).

Ankylosing spondylitis

Ankylosing spondylitis is the most common sero-negative arthropathy that is reported in paleopathological literature, though misdiagnoses are frequent particularly among the earlier cases (Resnick 1995; Rogers 1995; Waldron 2001; Waldron 2009). This disease is characterized by an inflammatory synovitis with the involvement of the entheses which results in bone erosion and joint ankylosis (Fletcher 1944; Buckley 1945; Resnick 1995; Rogers 1995; Sieper et al. 2002; Waldron 2009). The exact aetiology of ankylosing spondylitis is unknown, though evidence of a genetic component of its pathogenesis has been
reported (Fletcher 1944; Buckley 1945; Wu et al. 1988; Resnick 1995; Rogers 1995; Brown 2009; Waldron 2009; Tam et al. 2010; Erdes 2011). Symmetric and bilateral fusion of the spine with squaring of the corners of fused joints is indicative of ankylosing spondylitis (Fletcher 1944; Buckley 1945; Steinbock 1976; Resnick 1995; Aufderheide and Rodriguez-Martin 1998; Waldron 2009). Ankylosing spondylitis is also referred to as ‘bamboo spine’ due to the resemblance of the fused spine to a bamboo, and can affect other joints as well (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009).

Figure 3.22. Ankylosing spondylitis. Photo from Waldron (2009, p.57).

**Gout**

Gout is an inflammatory joint disease caused by an excess of uric acid in the blood which leads to the inflammation of joints (Resnick 1995; Rogers 1995; Aufderheide and
Gout on skeletal remains is marked by the presence of overhanging, hook-like erosive lesions near joint surfaces and is usually asymmetric (Martel 1968; Steinbock 1976; Resnick 1995; Rogers 1995; Aufderheide and Rodríguez-Martín 1998; Gentili 2003; Ortner 2003; Monu and Pope 2004; Waldron 2009). These regions may have sclerotic margins and osteoporosis is not present (Resnick 1995; Rogers 1995; Gentili 2003; Waldron 2009).

**Figure 3.23.** Radiograph of gout on a hand joint with the hook-like lesions marked by the arrow. Photo from www.learningradiology.com (LearningRadiology.com 2002).

**Diffuse Idiopathic Skeletal Hyperostosis (DISH)**

Diffuse Idiopathic Skeletal Hyperostosis refers to the ankylosis of the lateral side (usually the right side) of vertebral bodies due to the ossification of the anterior longitudinal ligament of the spine (Resnick et al. 1975; Utsinger et al. 1976; Resnick 1995; Rogers 1995; Waldron 2001; Waldron 2009). Aetiological factors of this disease include obesity, diabetes, abnormal vitamin A metabolism and a highly sedentary way of life (Resnick et al. 1975; Utsinger et al. 1976; Resnick 1995; Rogers 1995; Miyazawa and Akiyama 2006; Waldron
DISH is found to be more prevalent among males and those over 40 years of age in historic populations (Steinbock 1976; Resnick 1995; Waldron 2009).

The presence of huge ‘candle-like’ bone extensions linking the lateral sides of vertebral bodies together is characteristic of DISH (Resnick et al. 1975; Utsinger et al. 1976; Resnick 1995; Rogers 1995; Ortner 2003; Waldron 2009). DISH may also be present on other joints such as the elbows and knees (Resnick et al. 1975; Resnick 1995; Ortner 2003; Mader et al. 2009).

![Figure 3.24. DISH on the spine. Photo from Ortner (2003, p.559).](image)

**Infectious Diseases**

Infectious diseases are caused by the presence of pathogens in a host organism and primarily affect the soft tissues of the host (Mims et al. 2001). Very few infections leave
marks on the bone and even fewer are found in skeletal populations (Rothschild and Martin 1993; Mays 2008; Waldron 2009). The infectious diseases discussed in this section are those that have been found among skeletal remains from past populations.

*Osteomyelitis*

Osteomyelitis is a general term used to describe any form of bone infection which results in the inflammatory destruction of bone (Rogers and Waldron 1989; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Sia and Berbari 2006; Waldron 2009). This infection can be due to either of the following sources: spread of infection through the bloodstream, direct spread from adjacent soft tissue or through injuries or animal bites and is commonly caused by the bacteria *Staphylococcus aureus* (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Sia and Berbari 2006; Waldron 2009). Osteomyelitis is marked by the presence of indicators of inflammatory destruction of bone such as bone resorption accompanied with remodelling (Steinbock 1976; Rogers and Waldron 1989; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Mays 2008; Waldron 2009). Osteomyelitis among children is commonly found on the tibia due to the looping of capillaries to supply nutrients to the growth plate (Shim and Leung 1986; Ortner 2003). These capillaries provide room for the bacteria to settle and gain access to the bone marrow to multiply (Shim and Leung 1986). The different forms of osteomyelitis include compound fracture osteomyelitis, vertebral osteomyelitis, and septic arthritis (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009).
Compound Fracture Osteomyelitis

Compound fracture osteomyelitis, as the name suggests, is the infection of bone due to a compound fracture (Penberthy 1947; Reynolds and Zaepfel 1948; Steinbock 1976; Ortner 2003; Sia and Berbari 2006; Waldron 2009). Among recent populations, this disease is more commonly found in the tibia among young men and is marked by the presence of lytic lesions with some new bone formation (Penberthy 1947; Reynolds and Zaepfel 1948; Waldron 2009).

Vertebral Osteomyelitis

Vertebral osteomyelitis is characterized by the infection of a single vertebra which may then spread to adjacent vertebrae and cause subluxation, vertebral collapse and kyphosis (Steinbock 1976; Jeanneret and Magerl 1994; Kutas et al. 1995; Stefanovski and Van Voris 1995; Strausbaugh 1995; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Kayani et al. 2004; Waldron 2009). This disease may involve some new bone formation and ankylosis of

Figure 3.26. Possible vertebral osteomyelitis. Photo from Ortner (2003, p.205).

**Septic Arthritis**

Septic arthritis refers to the spread of infection along bone joints (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Nade 2003; Ortner 2003; Waldron 2009). Infection, usually caused by *S. aureus*, causes the soft tissue between adjacent joints to become swollen and inflamed and results in the destruction of the articular cartilage (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Nade 2003; Sinha et al. 2006; Waldron 2009). If left untreated, this leads to the erosion of joint surfaces and bony ankylosis (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Nade 2003; Sinha et al. 2006; Waldron 2009). The hips and knees are the most commonly affected areas in current populations and this disease is marked by the combination of bone resorption and new bone formation on the affected joints (Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009).
Tuberculosis and Brucellosis

Tuberculosis is an infectious disease that primarily affects the respiratory system and is commonly caused by *Mycobacterium tuberculosis* (Steinbock 1976; Rogers and Waldron 1989; Rothschild and Martin 1993; Bloom 1994; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Roberts and Buikstra 2003; Waldron 2009; Raviglione 2010; Hannu 2011; Roberts 2012). Bacterial strains mainly attack the lungs and may spread to different parts of the body (Steinbock 1976; Rogers and Waldron 1989; Rothschild and Martin 1993; Bloom 1994; Aufderheide and Rodriguez-Martin 1998; Waldron 2009; Raviglione 2010). Thus, the vertebrae and the ribs are the commonly affected regions of the skeleton (Kelley and Micozzi 1984; Pertuiset et al. 1999; Matos and Santos 2006). While tuberculosis is a common disease of the poor, the proportion of individuals with tuberculosis who develop skeletal lesions is small (Pertuiset et al. 1999; Sequeira et al. 2000; Mkandawire and Kaunda 2005; Stone et al. 2009). The presence of lytic lesions on multiple vertebral bodies with no new bone formation is typical of tuberculosis (Steinbock 1976; Rogers and Waldron 1989; Pertuiset et al. 1996; Aufderheide and Rodriguez-Martin 1998; Sequeira et al. 2000; Ortner 2003; Roberts and Buikstra 2003; Waldron 2009; Roberts 2012). It is mostly the vertebral bodies that are affected by this disease and the posterior arches of the vertebrae are usually left unaffected (Narlawar et al. 2002). Ankylosis, vertebral collapse and angular kyphosis may also be
observed among individuals with tuberculosis (Pertuiset et al. 1996; Aufderheide and Rodriguez-Martin 1998; Sequeira et al. 2000; Ortner 2003; Roberts and Buikstra 2003; Waldron 2009). Apart from the vertebrae and ribs, the infection can spread to adjacent bones and joints such as the hips and knees (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Aggarwal et al. 2001; Dhammi et al. 2003; Waldron 2009). Unifocal joint fusion with little or no new bone formation on the joints is indicative of tuberculous arthritis (Malaviya and Kotwal 2003; Waldron 2009). The presence of lytic lesions with practically no new bone formation on the extra-spinal skeleton is also characteristic of tuberculosis (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Waldron 2009).

Brucellosis is an infectious disease due to contact from animals with Brucella bacteria (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Corbel 2006; Waldron 2009; D'Anastasio et al. 2011). It is marked by similar lesions as tuberculosis, though the bone resorption is typically accompanied by new bone formation and is rarely found on the spine and more commonly seen on the hip and knee joints (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Capasso 1999; Ortner 2003; Bodur et al. 2004; Pourbagher et al. 2006; D'Anastasio et al. 2009; Waldron 2009; D'Anastasio et al. 2011).

Figure 3.28. Lytic lesions typical of tuberculosis on the spine. Photo from Ortner (2003, p.234).
Treponematosis

Treponemal disease or treponematosis is a general term used to describe infections caused by the bacteria *Treponema palladium* (Hackett 1976; Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Powell and Cook 2005b; Waldron 2009; Cook and Powell 2012). Treponemal disease is prevalent among past and present populations (Quetel 1990; Antal et al. 2002; Baker 2005; Molto 2005; Powell and Cook 2005a; Cook and Powell 2012). The different types of treponemal disease include venereal syphilis (*Treponema palladium palladium*), bejel or endemic syphilis (*Treponema palladium endemicum*), pinta (*Treponema palladium carateum*) and yaws (*Treponema palladium pertenue*) (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Among these, only pinta does not affect bone (Steinbock 1976; Ortner 2003; Waldron 2009). Venereal syphilis is transferred through sexual contact or childbirth, bejel is transmitted through mouth-to-mouth contact and yaws is spread through direct person-to-person contact (Hackett 1976; Marboe et al. 1976; Steinbock 1976; Judge et al. 1986; Judge 1988; Rogers and Waldron 1989; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Antal et al. 2002; Ortner 2003; Waldron 2009). Treponemal disease has an extensive history and various arguments regarding the origin and spread of this disease during pre- and post-colonial times have been presented (Hackett 1963; Baker and Armelagos 1988; Quetel 1990; Luger 1993; Rothschild et al. 2000; Meyer et al. 2002; Powell and Cook 2005a; Rothschild 2005; Erdal 2006; von Hunnius et al. 2006; Harper et al. 2011; Cook and Powell 2012).

The skeletal changes caused by treponemal disease typically appear during the tertiary stage of the disease (Hackett 1976; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009) though some skeletal manifestation and joint changes may be seen during the primary and secondary stages (Reginato 1993; Gurland et al. 2001). These changes include the presence of active lytic lesions with formation of periosteal new bone and radial scarring (caries sicca) (Hackett 1976; Marboe et al. 1976; Steinbock 1976; Turk 1995; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). These lesions are commonly found on the skull and the tibia of the infected individual (Hackett 1976; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Saber tibia, the deformation of tibia due to the formation of gumma and periostitis, without actual bowing is also indicative of syphilis (Hackett 1976; Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Evidence of congenital syphilis includes the presence of Hutchinson’s teeth, which are notches on the occlusal surface of
incisors and Moon’s or mulberry molars, the multiple rounded undeveloped cusps on the first permanent molars (Bernfeld 1971; Steinbock 1976; Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Hillson et al. 1998; Ortner 2003; Waldron 2009). Differentiating among the different kinds of treponemal disease is rather difficult as all forms exhibit similar lesions, however certain types of treponemal disease were found to be more common in specific areas of the world (Hackett 1963; Luger 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009; Cook and Powell 2012).

Figure 3.29. Cranial lesions characteristic of treponemal disease. Photos from Ortner (2003, p. 281).
Leprosy

Leprosy is an infectious disease caused by *Mycobacterium leprae* (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009; Lynnerup and Boldsen 2012). Leprosy affects mainly the peripheral nervous system and the mucous membrane of the upper respiratory tract (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Girdhar 2005; Waldron 2009; Lynnerup and Boldsen 2012). This disease is currently thought to be transmitted through nasal or oral secretions, though the exact mode of transmission has yet to be fully clarified (Britton and Lockwood 2004; Girdhar 2005; Stone et al. 2009; Waldron 2009).
Leprosy is characterized by the presence of skin lesions which spreads to the skeletal system if left untreated (Paterson and Rad 1961; Kumarasinghe 2001; Britton and Lockwood 2004; Girdhar 2005; Monot et al. 2005; Waldron 2009; Lynnerup and Boldsen 2012). This disease has a long-standing history and is believed to have originated from eastern Africa or the Near East and spread throughout Europe, Asia and eventually to America (Lechat 1999; Monot et al. 2005; Stone et al. 2009; Waldron 2009).

Leprosy is marked by the presence of rhinomaxillary syndrome or an “empty nose” appearance of the face due to bone resorption (Paterson and Rad 1961; Moller-Christensen 1965; Steinbock 1976; Andersen 1992; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Dave et al. 2004; Waldron 2009; Lynnerup and Boldsen 2012). The concentric loss of bone from the hands and feet, osteomyelitis of foot bones, destruction of the anterior nasal spine, nasal conchae and nasal septum, and the resorption of the alveolar processes at the center of the maxilla extending to the central incisors are common secondary bone changes due to complications from leprosy (Paterson and Rad 1961; Moller-Christensen 1965; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Dave et al. 2004; Moonot et al. 2005; Waldron 2009; Lynnerup and Boldsen 2012). Resorption and remodelling of the nasal aperture margins and pitting on the palatine processes of the maxilla can also be seen among individuals infected with this disease (Paterson and Rad 1961; Moller-Christensen 1965; Andersen 1992; Aufderheide and Rodriguez-Martin 1998; Dave et al. 2004; Waldron 2009; Lynnerup and Boldsen 2012).

*Figure 3.31. Rhinomaxillary syndrome and erosion of the hand phalanges in an individual with leprosy. Photos from Ortner (2003, p.266).*
Smallpox

Smallpox is an infectious disease caused by the Variola virus (Dixon 1951; Koplow 2003; Ortner 2003). This disease has a very illustrious history as the first one for which a vaccine was developed and also as the only disease to have been eradicated as a human pathogen (Fenner 1993; Rothschild and Martin 1993; Fenner 1996b; Fenner 1996a; Aufderheide and Rodriguez-Martin 1998; Koplow 2003; Ortner 2003; Waldron 2009). Evidence of smallpox extends to as far back as the dynastic period of Egypt where large populations enabled the pathogen to survive and spread among humans (Fenner 1993; Fenner 1996a; Henderson 1999; Ortner 2003). Smallpox is transmitted through human-to-human contact or through direct contact with infected bodily fluids or contaminated objects such as blankets and clothing (Dixon 1951; Fenner 1993; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Henderson 1999; Koplow 2003; Waldron 2009).

Smallpox, although rarely seen in skeletal remains, is typically characterized by the presence of periosteal new bone formation and is commonly found bilaterally on the elbows (Cockshott and Macgregor 1958; Davidson and Palmer 1963; Cockshot.Wp 1965; Aufderheide and Rodriguez-Martin 1998; Henderson 1999; Ortner 2003; Waldron 2009). Necrotic osteomyelitis and arthritis of the affected joints may also be present (Cockshott and Macgregor 1958; Davidson and Palmer 1963; Cockshot.Wp 1965; Aufderheide and Rodriguez-Martin 1998; Henderson 1999; Ortner 2003). The presence of bilateral lesions resulting from systemic infection on the distal humerus and proximal radius and ulna is characteristic of smallpox, which is rather uncommon in other forms of osteomyelitis (Cockshott and Macgregor 1958; Davidson and Palmer 1963; Cockshot.Wp 1965; Henderson 1999; Ortner 2003; Waldron 2009).

Polio

Poliomyelitis, which is caused by an RNA enterovirus, is a viral disease that affects the nerves and causes partial or full paralysis (Melnick 1996; Aufderheide and Rodriguez-Martin 1998; Johnson 1998; Waldron 2009). This disease is transmitted through direct person-to-person contact, contact with infected nasal or oral mucus, or contact with infected fecal material (Aufderheide and Rodriguez-Martin 1998; Johnson 1998; Waldron 2009).

The asymmetric inflammation of the limbs (usually the lower limb) and deformation of the affected limb is characteristic of polio (Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Evidence of osteoporosis may be present on the affected limb.
and an increase in the femoral neck angle is observed on the affected part (Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). These changes are commonly seen among juvenile skeletons when an individual is infected during growth (Aufderheide and Rodriguez-Martin 1998; Waldron 2009). Among adults, no difference in the size of the limb bones can be seen although the affected bone may show signs of osteoporosis and are usually more gracile than the unaffected limb due to atrophy from disuse (Aufderheide and Rodriguez-Martin 1998; Waldron 2009).

![Image of lower limbs](image)

*Figure 3.32. Lower limbs of an individual possibly infected by polio. The right limbs are shorter and more gracile than the left limbs suggesting that this individual was infected during growth. Photo from Waldron (2009, p. 110).*

**Malaria**

Malaria is a vector-borne infectious disease common in tropical and sub-tropical regions (Aufderheide and Rodriguez-Martin 1998; White 2003; Waldron 2009). There is no specific skeletal lesion that is indicative of malaria. However, since anemia is one of the main
symptoms of malaria, skeletal reactions suggestive of anemia can reflect the presence of malaria (Aufderheide and Rodriguez-Martin 1998; White 2003; Waldron 2009). These bone reactions include the swelling of the bone marrow to accommodate an increased production of red blood cells and cribra orbitalia, the pitting and formation of spongy bone on the roof of the orbits (Ortner 2003; Brickley and Ives 2008; Waldron 2009; Oxenham and Cavill 2010). Since the development of cribra orbitalia depends on multiple factors (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009; Walker et al. 2009; Oxenham and Cavill 2010), its aetiologies are discussed under the section on non-specific indicators of stress in this chapter.

Non-specific infections

Non-specific infections commonly seen in skeletal remains include periostitis and sinusitis. Periostitis refers to the inflammation of the periosteum, the outer membrane of bone, and may or may not be due to an infection (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). This disease is marked by the formation of sclerotic new bone on affected areas (Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Sinusitis is characterized by the inflammation of the frontal sinuses (Pott’s puffy tumor) resulting in the swelling of the forehead and the presence of osteoblastic lesions on the sinus floor (Aufderheide and Rodriguez-Martin 1998; Waldron 2009).

Periostitis and periosteal bone reactions are commonly linked to different infectious and metabolic diseases (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009; Weston 2012). The presence of these bone changes without other markers of more specific diseases are usually subsumed under non-specific infections in the paleopathological literature (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009; Weston 2012). However, periosteal reactions can occur as an inflammatory response to injuries other than that caused by infections (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009; Weston 2012). Thus, caution must be taken in carrying out a differential diagnosis from skeletal remains with periosteal reactions (Weston 2012).
**Metabolic Diseases**

Metabolic diseases are commonly marked by new bone growth or resorption and deformation of bone due to inadequate nutrition (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009). Different types of metabolic disease include osteoporosis, Paget’s disease, scurvy, rickets, osteomalacia and thyroid diseases (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009). The diseases reviewed in this section are among those commonly found in skeletal remains from archaeological sites.

**Osteoporosis**

Osteoporosis refers to the loss of the mineral component (hydroxyapatite) of bone which results in thin, brittle bones that are more prone to injury (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Brickley and Ives 2008; Waldron 2009). This disease is commonly linked to aging, particularly among menopausal women whose sudden imbalance in hormonal levels result in excessive osteoclast formation which leads to bone loss (Rothschild and Martin 1993; Mays 1996; Aufderheide and Rodriguez-Martin 1998; Mays 2000; Brickley and Ives 2008; Waldron 2009). Osteopenia, the condition wherein bone mass is lost, is a precursor to osteoporosis, though not all individuals with osteopenia develop osteoporosis (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Brickley and Ives 2008). There are two types of primary osteoporosis and both types are more commonly found among women of old age than men in modern populations (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009).

Evidence of osteoporosis is difficult to see by way of a visual examination of bone as the loss of bone density usually affects the trabecular part of the bone and may not be seen outside (Steinbock 1976; Melton et al. 1986; Aufderheide and Rodriguez-Martin 1998; Brickley and Howell 1999; Ortner 2003; Agarwal et al. 2004; Brickley and Ives 2008; Waldron 2009). However, a general lightness in weight of affected bone and thinning of the cortical bone may be observed from individuals suffering from this illness (Lees et al. 1993; Mays 1996; Mays 1998; Mays 2000; Ortner 2003; Gonzalez-Reimers et al. 2004; Brickley and Ives 2008; Waldron 2009). The first type of osteoporosis is marked by mainly trabecular bone loss with wrist and crush vertebral fractures (Riggs and Melton 1986; Brickley and Howell 1999; Ortner 2003; Agarwal et al. 2004; Waldron 2009). The second type involves
both trabecular and cortical bone loss with hip and wedge vertebral fractures (Riggs and Melton 1986; Brickley and Howell 1999; Ortner 2003; Agarwal et al. 2004; Brickley and Ives 2008; Waldron 2009). Secondary osteoporosis is caused by another underlying disease and affects both men and women equally (Riggs and Melton 1986; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009).

![Figure 3.33. A comparison of the cross section of a normal femur (top) and an osteoporotic femur (bottom). Photo from Ortner (2003, p. 412).](image)

**Scurvy**

Scurvy is a metabolic disease caused by a lack of vitamin C in the body (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009). Vitamin C is a water-soluble antioxidant and an electron donor for enzymes responsible for collagen synthesis (Rothschild and Martin 1993; Prockop and Kivirikko 1995; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009). While other animals have the ability to synthesize their own vitamin C, humans cannot synthesize and store vitamin C and are thus dependent on a constant supply from a daily diet (Lind 1753; Watt 1978; Crawford 1988; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Sutton 2003; Brickley and Ives 2008; Waldron 2009). Since vitamin C is linked to the production of blood and the metabolism of iron and folate, individuals with deficiency in vitamin C would most likely develop anemia.
(Brickley and Ives 2008; Waldron 2009). The loss of this vitamin in the body leads to malaise, lethargy, formation of spots on the skin, bleeding of gums and jaundice which if left untreated can result in neuropathy and even death (Lind 1753; Watt 1978; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Pimentel 2003; Sutton 2003; Brickley and Ives 2008; Waldron 2009).

Enlarged, porous epiphyses and the formation of periosteal new bone on the skull are characteristic signs of scurvy (Ortner and Ericksen 1997; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Fain 2005; Brickley and Ives 2008; Waldron 2009). Radiological indicators of this disease include the presence of a dense white line in the distal metaphysis (Fraenkel line), a line of decreased density behind the Fraenkel line which indicates trabecular bone loss, Pelkan’s spurs or periosteal new bone formation around the metaphysis, and a dense line of calcification around the epiphysis (Wimberger’s line) (Aufderheide and Rodriguez-Martin 1998; Tamura et al. 2000; Akikusa et al. 2003; Ortner 2003; Brickley and Ives 2008; Waldron 2009). An abnormal porosity of the cortex of the sphenoid, mandible, maxilla and the orbits may also be present as well as some new bone formation on the orbits and cranial vault (Rothschild and Martin 1993; Ortner and Ericksen 1997; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009).

Figure 3.34. Diffuse porous lesions on the cranium of an infant with scurvy. Photo from Ortner (2003, p.386).
Rickets and osteomalacia are metabolic diseases caused by the lack of vitamin D among children and adults respectively (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009). Vitamin D deficiency primarily develops due to inadequate absorption of nutrients but may also be hereditary (Chesney 2001; Brickley and Ives 2008; Aljubeh et al. 2011; Yan et al. 2011; Sun et al. 2012).

The failure of proper mineralization of bone during growth results in the bowing of leg bones, swelling at the costochondral junctions (rachitic rosary), and thinning of the skull bones, and the presence of enlarged, cupped and fraying, porous epiphyses on long bones (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Reginato and Coquia 2003; Mays et al. 2006; Mays et al. 2007; Brickley and Ives 2008; Waldron 2009). Among adults, osteomalacia is marked by the deformity of bones particularly in advanced cases, and the presence of Looser’s zones, otherwise called the milkman syndrome which appears as radiolucent areas which are areas of unmineralized osteoid which may appear as pseudo-fractures (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Mawer and Davies 2001; Ortner 2003; Reginato and Coquia 2003; Brickley and Ives 2008; Waldron 2009; Brickley et al. 2010). The ribs and hip bones are commonly affected by osteomalacia while the limb bones and the skull are usually affected by rickets (Aufderheide and Rodriguez-Martin 1998; Mawer and Davies 2001; Ortner 2003; Reginato and Coquia 2003; Brickley and Ives 2008; Waldron 2009).

Figure 3.35. Subperiosteal bone formation on a subadult with rickets (left) and an adult femur with healed osteomalacia (right). Photos from Ortner (2003, p. 395 & 402).
Skeletal lesions caused by trauma can be differentiated from those caused by disease due to the differences in nature of these lesions. Lesions from trauma are usually smaller and affect a more limited area while lesions caused by disease are more diffused (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Hamblen and Simpson 2007; Waldron 2009; Judd and Redfern 2012). Trauma is marked by the breakage of bone resulting from injury and is thus much localized compared to lesions caused by diseases (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Hamblen and Simpson 2007; Sanders 2008; Waldron 2009; Judd and Redfern 2012). There are many different types of trauma which leaves marks on the skeleton, which includes fractures and dislocations, joint dislocations and subluxations, wounding through sharp or blunt force trauma, gunshot wounding, amputation, trephinations, and trauma due to beheading and hanging (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Hamblen and Simpson 2007; Sanders 2008; Waldron 2009; Judd and Redfern 2012). Trauma can be broadly classified into two categories: accidental and deliberate. Accidental trauma includes fractures and dislocations which usually result from unintentional injuries while deliberate traumas are those caused by premeditated assaults such as gunshot wounds or those from surgical procedures such as trephination and amputation (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Hamblen and Simpson 2007; Sanders 2008; Waldron 2009).

Further complications from fractures include non-union, mal-union leading to shortening and deformity of the affected part, infection and avascular necrosis particularly on the femoral head, scaphoid, lunate and talus (Mays 1998; Hamblen and Simpson 2007; Sanders 2008; Waldron 2009). These lesions are usually deliberate and are commonly accompanied with evidence of remodelling particularly on the margins (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Waldron 2009). Bone fractures are broadly classified into two types: simple and compound fractures (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Hamblen and Simpson 2007; Sanders 2008; Waldron 2009). Simple or closed fractures refer to the bone fractures where the skin is still intact while compound or open fractures refer to those where skin breakage is involved which leads to a higher risk of infection (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Waldron 2009). Fractures are further classified into transverse, oblique, spiral, depressed, crush, wedge, greenstick, pathological and stress which basically describes the placement of the fracture along the bone and/or the nature or appearance of the fracture.
The healing phase of fractures can be divided into three parts: the inflammatory phase, the reparative phase and the remodelling phase (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Hamblen and Simpson 2007; Waldron 2009). During the inflammatory phase, a hematoma is formed around the affected area (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Hamblen and Simpson 2007; Waldron 2009). The formation of a flexible fibrous tissue then follows which bridges the break between the bone ends and allows the hematoma to be resorbed (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Hamblen and Simpson 2007; Waldron 2009). Finally, osteoblastic action results in the formation of callous new bone on the affected area to replace the fibrous union while osteoclasts remove dead bone from the fracture site (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Hamblen and Simpson 2007; Waldron 2009). This callous new bone then undergoes remodelling and the medullary cavity is reformed (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Hamblen and Simpson 2007; Waldron 2009).

Gunshot wounds usually result in comminuted fractures with a clean entry wound and beveling on exit wounds (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Waldron 2009). Trephination involves deliberate removal of pieces of bone from the skull which may be accompanied by some remodelling on the margins of the lesion (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Waldron 2009). Cut marks on the bone can usually be seen among individuals who underwent amputation or have been beheaded (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Waldron 2009). The fracture or dislocation of the axis of the vertebrae is indicative of hanging (Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Waldron 2009).

**Oral Pathologies**

All available teeth from each individual were recorded for its presence, stage of wear, and crown height. Numerous sources on oral pathology were consulted to comprehend the variety of lesions found on teeth and how to record these lesions (Steinbock 1976; Rothschild and Martin 1993; Buikstra et al. 1994; Hillson 1996; Alt et al. 1998; Cox and Mays 2000; Ortner 2003; Mays 2008; Waldron 2009). Dental lesions such as the presence of caries, calculus, linear enamel hypoplasia, periapical cavities, evidence of staining, and alveolar resorption were recorded (Buikstra et al. 1994; Hillson 1996). The degree of tooth affected with these lesions were noted using a nominal scale of 1 to 3 where one means the lesion is rather small and affected less than 25% of the tooth, two means the lesion affected 25%-75%
of the tooth, and three means the lesion is large and affected more than 75% of the tooth. The location of these lesions on the teeth and surrounding bone were also recorded. For children and adolescents, all observable deciduous teeth were recorded along with the permanent dentition if there are any that were present. Photographs of teeth with observable lesions were taken to supplement written records.

Different types of oral conditions can be diagnosed by the macroscopic examination of dentition. Caries, antemortem tooth loss, periodontal disease, calculus, periapical lesions and developmental defects can be identified due to their distinct manifestations on teeth.

**Caries**

Caries refers to the destruction of teeth due to infection from cariogenic bacteria, which leads to the formation of cavities on the enamel or the root surface (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). The infection causes demineralization of the affected tooth which results in the destruction of the organic component of the tooth (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). This is caused mainly by an individual’s diet and oral hygiene (Hillson 1996; Ortner 2003; Waldron 2009). Frequent exposure to food that is high in cariogenic components such as sugar and other fermentable carbohydrates are the primary cause of dental caries (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009).

Caries is marked by a white or brown spot on the enamel or a hollowed portion with sharp, well-defined edges that are generally deeper in relation to its width (Hillson 1996; Mays 1998; Waldron 2009). Cavities on the crown and root region of teeth are generally indicative of caries (Hillson 1996; Ortner 2003; Waldron 2009). Dental caries are more commonly found on the crown than the root of the teeth since the crown is more exposed to the bacteria and cariogenic particles (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Figure 3.36 shows an example of caries on the right permanent maxillary canine.

Circular caries refer to the caries found on the enamel of the deciduous teeth of children due to poor enamel formation (Cook and Buikstra 1979; Blakey and Armelagos 1985; Cook 1990). Enamel hypocalcification is due to the disruption in mineralization of the enamel and is usually seen as an “opaque (chalky white or yellow-brown) transverse band of enamel” (Blakey and Armelagos 1985, p.372). The hypocalcification of enamel during its
development makes the teeth weak and thus predisposed to caries during childhood (Cook and Buikstra 1979; Blakey and Armelagos 1985; Cook 1990). Enamel hypocalcification is an enamel defect similar to hypoplasia which is commonly seen among individuals from poor populations (Cook and Buikstra 1979; Cook 1990). Since part of the enamel of deciduous teeth are formed while an infant is still in utero, enamel hypocalcification is an indicator of poor maternal health (Cook and Buikstra 1979; Cook 1990).

![Figure 3.36. Dental caries on the right permanent maxillary canine of individual 21 from Sibaltan. Photo taken by author.](image)

**Calculus**

Calculus refers to the deposition of mineralized plaque commonly found on the lingual surface of the teeth (Hillson 1996; Mays 1998; Waldron 2009). Dental calculus develops in an alkaline environment which is why it is more commonly found on the lingual surfaces of anterior teeth since that area is the most alkaline part of the mouth (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Dawes 1998; Ortner 2003; Waldron 2009). Poor oral hygiene usually results in the formation of dental plaque and an inverse relationship between dental hygiene and dental calculus has been found (Dobney and Brothwell 1986; Hillson 1996; White 1997; Aufderheide and Rodriguez-Martin 1998; White 2000; Ortner 2003; Waldron 2009). An example of calculus on teeth is shown in Figure 3.37.

Examining the presence of calculus on archaeological remains poses problems regarding the preservation and other taphonomic process that might affect the teeth of the individuals (Ortner 2003; Waldron 2009). Sites with high calcareous concentrations on the soil can leave deposits on teeth which look similar to calculus while other sites with very
compact soil matrix makes it difficult to remove soil particles that were attached on the teeth, thus making observation difficult and sometimes impossible.

Figure 3.37. Dental calculus on mandibular teeth. Photo from the Museum of London website (Henderson 2008).

**Antemortem Tooth Loss (AMTL)**

Antemortem tooth loss, as the name suggests, refers to the loss of teeth while an individual was still alive. The loss of teeth may be due to a number of things such as impaction of teeth, deliberate ablation as part of cultural ritual or custom, or loss due to disease (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). The presence of indicators of periodontal disease can help in inferring the aetiology of the tooth loss, otherwise the specific aetiology cannot be known based solely on skeletal remains (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009).

AMTL is commonly inferred through the remodelling and resorption of tooth sockets (Hillson 1996; Mays 1998; Waldron 2009).
Alveolar Resorption

The recession of alveolar margins with evidence of inflammation and remodelling is indicative of periodontal disease (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Mays 1998; Ortner 2003; Waldron 2009). Periodontal disease can be classified into two categories: gingivitis and periodontitis (Kinane 2000; Armitage 2004; Pihlstrom et al. 2005). Gingivitis refers to the inflammation of the gums due to pathogenic bacteria in dental plaque while periodontitis is a more severe form of periodontal disease which affects the tissues surrounding and supporting the teeth (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Kinane 2000; Page 2002; Ortner 2003; Armitage 2004; Pihlstrom et al. 2005; Waldron 2009).

The recession of the alveolar bone and exposure of the roots of the teeth indicates the presence of periodontal disease (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Evidence of inflammation and remodelling may also be seen on affected areas (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Figure 3.39 shows an example of alveolar resorption and exposure of the roots of the mandibular incisors and canines.
Figure 3.39. Alveolar resorption on the mandible leading to exposure of the roots of the teeth. Mandible from individual 21 from Sibaltan. Photo taken by author.

Periapical lesions

Osteolytic lesions on the alveolar bone develop due to the inflammation of the periapical tissues usually due to infections (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Periapical cavities are categorized into three types according to size: granuloma, cyst and abscess (Hillson 1996; Ramachandran Nair et al. 1996; Mays 1998; Waldron 2009). Periapical granuloma refers to small lesions less than three millimeters in diameter with circumscribed margins and smooth walls while periapical cysts are usually larger but have similar characteristics (Hillson 1996; Dias and Tayles 1997; Mays 1998; Waldron 2009). Periapical abscess is marked by roughened walls and are generally larger in size (Hillson 1996; Dias and Tayles 1997; Mays 1998; Waldron 2009).
Non-specific indicators of stress

Non-specific indicators of stress refer to markers on the skeleton and teeth which are affected by poor health and nutrition during growth (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). These include the presence of linear enamel hypoplasia, vertebral neural canal size, reduced adult stature, Harris lines, and cribra orbitalia (Rothschild and Martin 1993; Ribot and Roberts 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009; Watts 2011). In this research, only linear enamel hypoplasia and cribra orbitalia were studied, and are thus reviewed below.

Linear Enamel Hypoplasia

Developmental defects of the enamel can be caused by a multitude of aetiologies including birth trauma, low birth weight, infections, systemic illnesses, and genetic factors (Hillson 1996; Mays 1998; Waldron 2009). Linear enamel hypoplasia (LEH) is the most common form of enamel defect and is generally used as an indicator of systemic stress during childhood and growth (Goodman and Rose 1991; Hillson 1996; Mays 1998; King et al. 2000; King et al. 2005; Slaus 2008; Waldron 2009). LEH is formed due to the deficiency in
ameloblasts, the cells responsible for the formation of the enamel, usually due to inadequate nutrition during growth (Hillson 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). LEH is marked by the presence of a single or multiple transverse lines or bands of depressed enamel on the sides of the tooth crown (Hillson 1996; Mays 1998; Waldron 2009). Figure 3.41 shows a typical example of LEH on a permanent incisor.

Figure 3.41. Linear enamel hypoplasia on the left central maxillary incisor of individual 2212 from Ille Cave. Photo taken by author.

**Cribra orbitalia**

Cribra orbitalia refers to the “sieve-like” lesions found on the roofs of the orbits, an example of which is shown in Figure 3.42, and is another indicator of stress particularly among young children (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009). The
formation of new bone due to cribra orbitalia is spongy in appearance which is different from new bone growth due to other diseases. Cribra orbitalia is formed due to the vascular activity in the area to accommodate the formation of more red blood cells (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009). Thus, cribra orbitalia is used as an indicator of anemia, although a study has suggested that anemia is not a cause of cribra orbitalia (Walker et al. 2009). However, another study has shown that while anemia may not be the only cause of cribra orbitalia, it can still be regarded as one of the possible factors in the formation of this lesion (Oxenham and Cavill 2010).

![Image of cribra orbitalia](image)

*Figure 3.42. Cribra orbitalia on the left orbit of individual 800 from Ille Cave. Photo taken by author.*

**Statistical Analysis**

Statistical analysis was carried out to assess the statistical significance of the difference in the prevalence of pathologies among the sites. Due to the small size of the sample, a more rigorous statistical test is needed to assess significance with the differences observed among the samples from the different sites (Fielding and Gilbert 2006; Levin and Fox 2006). The Fisher’s exact test was used as this method of statistical analysis is more
suitable for samples of small size (Fielding and Gilbert 2006; Levin and Fox 2006). GraphPad Prism statistical software was used for statistical analysis.

**Chapter Summary**

This chapter has presented the archaeological background of the materials used in this thesis. The methods used in the examination of the skeletal samples were also discussed as well as the different diseases which causes skeletal lesions. The different oral pathologies and their aetiologies were also presented. The next chapter presents the results of the examination of these skeletal remains.
Chapter 4 – RESULTS

This section provides the findings from the examination on the different skeletal samples from the Philippines. For comparative purposes, samples from similar time periods were combined to increase sample size. Thus, the samples from Ille Cave, Sibaltan and Bongabong were grouped together since the burials from these sites were dated to the early Spanish period. This brings the total number of individuals from the early Spanish period to 32, while 18 individuals from the pre-colonial site of Catanauan were examined. The samples from Catanauan will be called pre-colonial samples while the samples from Ille Cave, Sibaltan and Bongabong will be called the Spanish period samples to address the aim of comparing the status of health between the two time periods.

Age and Sex Estimation

Pre-colonial samples

Due to the highly fragmented nature of the remains from the pre-colonial sample, the number of unknown aged adults was the highest, making up 66% of the sample. These adults of unknown age were mainly those excavated from the trench that was previously disturbed by treasure hunting activities and from layers where human remains were present but which may not be burials. These remains usually included only cranial or long bone fragments which made it difficult to assess sex. Mid-aged adults made up 22% of the sample, and adolescents and young adults both included 6% of the sample. There were no children or old adults present in the sample, and only one adolescent was identified. During earlier excavations, the recovery of a few child burials was recorded; however these were not examined because the child remains could not be found in the storage.

There were more males than females present in the sample from the pre-colonial period as shown in Table 4.2. Only a single individual was assessed as female in the sample. As mentioned earlier, the high number of individuals of unknown sex is due to the poor preservation of the remains. The adolescent was not included in Table 4.2 since subadults were not sexed.
Table 4.1. The distribution of individuals from the pre-colonial sample according to age.

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Pre-colonial burials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Children &lt;6 years</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Children &gt;6 years</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adolescents (13 – 18 years)</td>
<td>1</td>
<td>5.56</td>
</tr>
<tr>
<td>Subtotal (subadults)</td>
<td>1</td>
<td>5.56</td>
</tr>
<tr>
<td>Young adults</td>
<td>1</td>
<td>5.56</td>
</tr>
<tr>
<td>Mid adults</td>
<td>4</td>
<td>22.22</td>
</tr>
<tr>
<td>Old adults</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unknown adults</td>
<td>12</td>
<td>66.67</td>
</tr>
<tr>
<td>Subtotal (adults)</td>
<td>17</td>
<td>94.44</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>100</td>
</tr>
</tbody>
</table>

Key: N – total number of individuals

Table 4.2. The distribution of adult individuals in the pre-colonial sample according to age and sex.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Males N</th>
<th>Males %</th>
<th>Females N</th>
<th>Females %</th>
<th>Unknown N</th>
<th>Total N</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young adults</td>
<td>1</td>
<td>5.88</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>5.88</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>3</td>
<td>17.65</td>
<td>1</td>
<td>5.88</td>
<td>0</td>
<td>4</td>
<td>23.53</td>
</tr>
<tr>
<td>Old adults</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Subtotal</td>
<td>4</td>
<td>23.53</td>
<td>1</td>
<td>5.88</td>
<td>0</td>
<td>5</td>
<td>29.41</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>70.59</td>
<td>12</td>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>4</td>
<td>1</td>
<td>12</td>
<td>70.59</td>
<td>12</td>
<td>17</td>
<td>100</td>
</tr>
</tbody>
</table>

Key: N – total number of individuals

Figure 4.1. The age at death distribution of individuals from the pre-colonial sample.
**Spanish period samples**

More than half of the individuals examined from the Spanish period burials were children, who made up 53% of the sample as shown in Table 4.3. This contributed to the high number of individuals with unknown sex since all children from all samples were not sexed. Among the adults, young adults were most common. The young adults made up 22% of the sample, while the mid adults comprised 9% of the sample and the old adults made up 3% of the sample. No adolescents were present from the Spanish period samples.

There were an equal number of individuals assessed as males and females from the Spanish period samples as seen in Table 4.4. However, the number of adults in the sample was rather small and made up less than half of the total sample size.

*Table 4.3. The distribution of individuals from the Spanish period samples according to age.*

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Spanish period burials</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Children &lt;6 years</td>
<td>14</td>
<td>43.75</td>
<td></td>
</tr>
<tr>
<td>Children &gt;6 years</td>
<td>3</td>
<td>9.38</td>
<td></td>
</tr>
<tr>
<td>Adolescents (13 – 18 years)</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal (subadults)</strong></td>
<td><strong>17</strong></td>
<td><strong>53.13</strong></td>
<td></td>
</tr>
<tr>
<td>Young adults</td>
<td>7</td>
<td>21.88</td>
<td></td>
</tr>
<tr>
<td>Mid adults</td>
<td>3</td>
<td>9.38</td>
<td></td>
</tr>
<tr>
<td>Old adults</td>
<td>1</td>
<td>3.13</td>
<td></td>
</tr>
<tr>
<td>Unknown adults</td>
<td>4</td>
<td>12.5</td>
<td></td>
</tr>
<tr>
<td><strong>Subtotal (adults)</strong></td>
<td><strong>15</strong></td>
<td><strong>46.88</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

*Key: N – total number of individuals*

*Table 4.4. The distribution of adult individuals in the Spanish period sample according to age and sex.*

<table>
<thead>
<tr>
<th>Age group</th>
<th>Males</th>
<th>Females</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>%</td>
<td>N</td>
<td>%</td>
</tr>
<tr>
<td>Young adults</td>
<td>1</td>
<td>6.67</td>
<td>5</td>
<td>33.33</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>3</td>
<td>20</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Old adults</td>
<td>1</td>
<td>6.67</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>5</td>
<td>33.33</td>
<td>5</td>
<td>33.33</td>
</tr>
<tr>
<td>Unknown</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>15</td>
</tr>
</tbody>
</table>

*Key: N – total number of individuals*
The very small number of individuals assessed as males and females made the comparison of the samples from different time periods according to sex difficult. This is due to the preservation of the skeletal remains, where most of the bones commonly used for sexing were in poor condition or missing. Among those assessed with a definite sex, few individuals were identified to have any sign of skeletal lesions.

**Preservation**

*Table 4.5. Preservation of individuals from the Pre-colonial period and the Spanish period.*

<table>
<thead>
<tr>
<th>Preservation</th>
<th>Pre-colonial</th>
<th>Spanish Period</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;25%</td>
<td>66.67%</td>
<td>34.38%</td>
</tr>
<tr>
<td>25%-75%</td>
<td>16.67%</td>
<td>21.88%</td>
</tr>
<tr>
<td>&gt;75%</td>
<td>16.67%</td>
<td>43.75%</td>
</tr>
</tbody>
</table>

As seen in Table 4.5, more individuals from the Spanish period were better preserved compared with those from the pre-colonial period. The difference in interment methods and the local environment might have had an impact on the difference of preservation of the skeletal remains.

**Skeletal Pathologies**

This section discusses the skeletal lesions found on the individuals from both samples and the pattern of these lesions according to age and sex. Case studies of two individuals with distinctive skeletal lesions are also presented.
**Pre-colonial samples**

Very few individuals from the pre-colonial sample had skeletal lesions. Only 3 individuals out of 18 had skeletal lesions, all of whom were adults. Two of these were mid-adult males and the other is an adult of unknown age and sex. Only one individual from the sample was assessed as female, and this individual did not exhibit any form of skeletal lesion. Overall, only 17% of the sample had evidence of skeletal lesions as seen in Table 4.6. All of the individuals examined had skeletal lesions on the lower limbs only. Two of these lesions are from degenerative changes on the foot, and the other lesion involves some bone deposition on the right femur.

Since the number of individuals with skeletal lesions is very small, the Fisher’s exact test was used to calculate the statistical significance of the differences by age and sex within the sample. However, no statistically significant difference was found.

*Table 4.6. The distribution of individuals with skeletal pathologies from the pre-colonial sample according to age.*

<table>
<thead>
<tr>
<th>Age group</th>
<th>Pre-colonial burials</th>
<th>A/O</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children &lt;6 years</td>
<td>0/0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Children &gt;6 years</td>
<td>0/0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Adolescents (13 – 18 years)</td>
<td>0/1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Subtotal (subadults)</td>
<td>0/1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Young adults</td>
<td>0/1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>2/4</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Old adults</td>
<td>0/0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Unknown adults</td>
<td>1/12</td>
<td>8.33</td>
<td></td>
</tr>
<tr>
<td>Subtotal (adults)</td>
<td>3/17</td>
<td>17.65</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3/18</td>
<td>16.67</td>
<td></td>
</tr>
</tbody>
</table>

*Subadults vs. Adults Fisher’s exact test p-value*

1.0000

Key: A – affected individuals, O – observed individuals.
Table 4.7. The distribution of adult individuals with skeletal pathologies from the pre-colonial sample according to age and sex.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Males</th>
<th>Females</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
<td>%</td>
</tr>
<tr>
<td>Young adults</td>
<td>0/1</td>
<td>0</td>
<td>0/0</td>
<td>0</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>2/3</td>
<td>66.67</td>
<td>0/1</td>
<td>0</td>
</tr>
<tr>
<td>Old adults</td>
<td>0/0</td>
<td>0</td>
<td>0/0</td>
<td>0</td>
</tr>
<tr>
<td>Subtotal</td>
<td>2/4</td>
<td>50</td>
<td>0/1</td>
<td>0</td>
</tr>
<tr>
<td>Unknown</td>
<td>0/0</td>
<td>0</td>
<td>0/0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>2/4</td>
<td>50</td>
<td>0/1</td>
<td>0</td>
</tr>
</tbody>
</table>

Males vs. Females Fisher’s exact test p-value

<table>
<thead>
<tr>
<th>Males vs. Females Fisher’s exact test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0000</td>
</tr>
</tbody>
</table>

Key: A – affected individuals, O – observed individuals.

Table 4.8. The location of skeletal pathologies from the pre-colonial sample according to age.

<table>
<thead>
<tr>
<th>Location of lesions</th>
<th>Young adults</th>
<th>Males</th>
<th>Mid-adults</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
</tr>
<tr>
<td>Cranial</td>
<td>0/1</td>
<td>0</td>
<td>0/4</td>
<td>0</td>
<td>0/8</td>
</tr>
<tr>
<td>Vertebral</td>
<td>0/0</td>
<td>0</td>
<td>0/3</td>
<td>0</td>
<td>0/0</td>
</tr>
<tr>
<td>Axial</td>
<td>0/1</td>
<td>0</td>
<td>0/4</td>
<td>0</td>
<td>0/3</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>0/1</td>
<td>0</td>
<td>0/4</td>
<td>0</td>
<td>0/8</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>0/1</td>
<td>0</td>
<td>2/4</td>
<td>50</td>
<td>1/9</td>
</tr>
</tbody>
</table>

Young adults vs. Mid-adults Fisher’s exact test p-value for the lower limbs

<table>
<thead>
<tr>
<th>Young adults vs. Mid-adults Fisher’s exact test p-value for the lower limbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0000</td>
</tr>
</tbody>
</table>

Key: A – affected individuals, O – individuals with observed skeletal elements.

Figure 4.3. Bone formation on the foot phalanx of mid-adult male T4C82 (left) and adult male T6C57 (right) from the pre-colonial sample. Photo taken by author.
Spanish period samples

More than half of the individuals examined from the Spanish period samples exhibited evidence of skeletal lesions. As seen in Table 4.8, slightly less than half of all subadults and adults had some form of pathology while over half of all adults examined had lesions. Among the adults, the old adults had the highest proportion of individuals with skeletal lesions followed by the young adults. However, only a single individual from the samples was identified as an old adult.

Overall, skeletal lesions on the lower limbs were most common, particularly the tibia since the majority of the subadults with lesions were mainly found on the tibia. In adults, most of the lesions were found on the skull and the lower limbs as shown in Table 4.10. Skeletal lesions were most prevalent among subadults and the prevalence decreases with age. However, the distribution of individuals according to age in the sample might have influenced this trend. Among subadults and mid-adults, the skeletal lesions were mainly found on the lower limbs while cranial lesions were most common in young adults. The single old adult from the sample had evidence of skeletal lesions on the vertebrae, upper limbs and lower
limbs. Vertebral lesions were more common among mid-adults and old adults than the other age groups. The young adults displayed the most variety of the location of lesions among all age groups, with lesions found on the skull, vertebral region, ribs and lower limbs. The skeletal lesions found on the old adult individual were all due to degenerative changes on the joints.

There were a slightly higher proportion of females with skeletal lesions than males in the Spanish period burials as seen on Table 4.9. Among males, the old adults had the highest proportion of individuals with skeletal lesions while the young adults had the highest proportion in females since there were no female mid-adults or old adults in the samples. In males, skeletal lesions were mainly found among mid-adults and old adults while in females, young adults were the most affected. However, since all of the individuals assessed as females were young adults, the proportions were skewed in favor of the young adult age group. Skeletal lesions in males were mainly found on the lower limbs followed by the vertebral region and the upper limbs while cranial lesions were most common in females. The location of lesions among males was more diverse than females, with evidence of lesions found on the vertebral region, the ribs and both upper and lower limbs.

For the statistical tests according to age, all adults (young adults, mid-adults and old adults) were combined to increase the sample size since the very small number of individuals in each age group would make statistical comparisons impossible. Overall, the difference in the prevalence of skeletal lesions between subadults and adults was not statistically significant. The overall difference in prevalence of skeletal lesions between males and females was not statistically significant, though the difference in prevalence of cranial lesions between the two sexes was statistically significant.
Table 4.9. The distribution of individuals with skeletal pathologies from the Spanish period samples according to age.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Spanish period burials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
</tr>
<tr>
<td>Children &lt;6 years</td>
<td>7/14</td>
</tr>
<tr>
<td>Children &gt;6 years</td>
<td>1/3</td>
</tr>
<tr>
<td>Adolescents (13 – 18 years)</td>
<td>0/0</td>
</tr>
<tr>
<td><strong>Subtotal (subadults)</strong></td>
<td>8/17</td>
</tr>
<tr>
<td>Young adults</td>
<td>5/7</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>2/3</td>
</tr>
<tr>
<td>Old adults</td>
<td>1/1</td>
</tr>
<tr>
<td>Unknown adults</td>
<td>1/4</td>
</tr>
<tr>
<td><strong>Subtotal (adults)</strong></td>
<td>9/15</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>17/32</td>
</tr>
</tbody>
</table>

Subadults vs. Adults Fisher’s exact test p-value

|                          | 0.5023 |

Key: A – affected individuals, O – observed individuals.

Table 4.10. The distribution of adult individuals with skeletal pathologies from the Spanish period samples according to age and sex.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Males</th>
<th>Females</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Young adults</td>
<td>0/1</td>
<td>4/5</td>
<td>1/1</td>
<td>6/7</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>80</td>
<td>16.67</td>
<td>71.43</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>2/3</td>
<td>0/0</td>
<td>0/0</td>
<td>2/3</td>
</tr>
<tr>
<td></td>
<td>66.67</td>
<td>0</td>
<td>0</td>
<td>66.67</td>
</tr>
<tr>
<td>Old adults</td>
<td>1/1</td>
<td>0/0</td>
<td>0/0</td>
<td>1/1</td>
</tr>
<tr>
<td></td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td><strong>Subtotal</strong></td>
<td>3/5</td>
<td>4/5</td>
<td>1/1</td>
<td>8/11</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>80</td>
<td>16.67</td>
<td>72.73</td>
</tr>
<tr>
<td>Unknown</td>
<td>0/0</td>
<td>0/0</td>
<td>1/4</td>
<td>1/4</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>0</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3/5</td>
<td>4/5</td>
<td>2/5</td>
<td>9/15</td>
</tr>
<tr>
<td></td>
<td>60</td>
<td>80</td>
<td>23.33</td>
<td>60</td>
</tr>
</tbody>
</table>

Males vs. Females Fisher’s exact test p-values

|                          | 1.0000 |

Key: A – affected individuals, O – observed individuals.

Table 4.11. The location of skeletal pathologies from the Spanish period samples according to age.

<table>
<thead>
<tr>
<th>Location of lesions</th>
<th>Subadults</th>
<th>Young adults</th>
<th>Mid-adults</th>
<th>Old adults</th>
<th>Unknown adults</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Cranial</td>
<td>1/12</td>
<td>3/5</td>
<td>0/3</td>
<td>0/1</td>
<td>0/0</td>
<td>4/21</td>
</tr>
<tr>
<td>Vertebral*</td>
<td>0/15</td>
<td>2/7</td>
<td>0/2</td>
<td>0/1</td>
<td>0/2</td>
<td>2/27</td>
</tr>
<tr>
<td>Axial</td>
<td>0/15</td>
<td>1/7</td>
<td>1/2</td>
<td>0/1</td>
<td>0/2</td>
<td>2/27</td>
</tr>
<tr>
<td>Upper limbs*</td>
<td>1/15</td>
<td>0/6</td>
<td>0/3</td>
<td>1/1</td>
<td>0/2</td>
<td>2/27</td>
</tr>
<tr>
<td>Lower limbs*</td>
<td>8/14</td>
<td>1/6</td>
<td>1/2</td>
<td>1/1</td>
<td>0/2</td>
<td>12/25</td>
</tr>
</tbody>
</table>

Key: A – affected individuals, O – individuals with observed skeletal elements. For the vertebral, upper limb and lower limb lesions, those due to degenerative changes were not included in this comparison and are discussed in the next section.
Table 4.1. Subadults vs. Adults Fisher’s exact test p-values for skeletal pathologies. All adult samples were combined to increase sample size. Skeletal lesions due to degenerative changes were not included in the comparison.

<table>
<thead>
<tr>
<th>Location of lesions</th>
<th>Subadults vs. adults p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial</td>
<td>0.2722</td>
</tr>
<tr>
<td>Vertebral</td>
<td>0.1880</td>
</tr>
<tr>
<td>Axial</td>
<td>0.1880</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>0.5692</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>0.4283</td>
</tr>
</tbody>
</table>

Table 4.13. The location of skeletal pathologies from the adult individuals of the Spanish period samples according to sex. Individuals with degenerative changes were included in this table.

<table>
<thead>
<tr>
<th>Location of lesions</th>
<th>Males</th>
<th>Females</th>
<th>Unknown</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
</tr>
<tr>
<td>Cranial</td>
<td>0/5</td>
<td>3/4</td>
<td>0/0</td>
<td>3/9</td>
</tr>
<tr>
<td>Vertebral</td>
<td>2/4</td>
<td>1/5</td>
<td>1/3</td>
<td>4/12</td>
</tr>
<tr>
<td>Axial</td>
<td>1/4</td>
<td>0/5</td>
<td>1/3</td>
<td>2/12</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>2/4</td>
<td>0/5</td>
<td>1/3</td>
<td>3/12</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>3/3</td>
<td>1/5</td>
<td>0/3</td>
<td>4/11</td>
</tr>
</tbody>
</table>

Key: A – affected individuals, O – individuals with observed skeletal elements.

Table 4.14. Males vs. Females Fisher’s exact test p-values for skeletal pathologies. P-values in **bold** indicates a statistically significant difference.

<table>
<thead>
<tr>
<th>Location of lesions</th>
<th>Males vs. Females p-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial</td>
<td><strong>0.0476</strong></td>
</tr>
<tr>
<td>Vertebral</td>
<td>0.5238</td>
</tr>
<tr>
<td>Axial</td>
<td>0.4444</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>0.1667</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>0.1429</td>
</tr>
</tbody>
</table>

Figure 4.5. The location of skeletal pathologies from the Spanish period samples according to age.
Figure 4.6. The location of skeletal pathologies from the Spanish period samples according to sex.
Figure 4.7. Two examples of cranial pathologies from the Spanish period burials. The top photo shows new bone formation on the endocranial surface of a subadult skull from burial 1807 from Ille Cave and the bottom photo shows remodelled cribra orbitalia from burial 21, a young adult female from Sibaltan. Photos taken by author.
Figure 4.8. Examples of skeletal pathologies from the lower limbs from the Spanish period burials. The top two photos show new bone formation on the left (top left) and right (top right) tibiae of individual 1807. The middle left and bottom left photos show new bone formation on the shaft of the right tibia of individuals 722 and 723 respectively. The middle right photo shows bone formation on the right femoral shaft of individual 2255 while the bottom right photo shows a similar formation on the femoral shaft of individual 2249. All the individuals from these photos were subadults under six years of age and were excavated from Ille Cave. Photos taken by author.

Degenerative Changes

Four individuals from the Spanish period burials exhibited lesions due to degenerative changes in the joints. Three of these individuals were males and one is an adult of unknown age and sex. Among the males with degenerative changes, two were mid-adults and one was an old adult. The degenerative changes were most commonly found on the vertebrae. The old adult individual (individual 2) had degenerative changes on the vertebrae, left distal femur and on an interphalangeal joint. A mid-adult male (individual 748) had porosity and
osteophyte formation on the left distal foot phalanx and another had degenerative changes on the cervical vertebrae (individual 2247). The adult individual of unknown sex (individual 2266) had some pitting and bone formation on the right radial head.

Figure 4.9. Two examples of joint pathologies on individuals from the Spanish period burials. The photo on the left shows extensive pitting and some osteophyte formation on the inferior body of a lower cervical vertebra of individual 2247, a mid-adult male from Ille Cave. The photo on the right shows the ankylosis of an interphalangeal joint of old adult individual 2 from Bongabong. Photos taken by author.

Summary of Skeletal Pathologies in the samples

Only 17% of the individuals from the pre-colonial burials had skeletal lesions, two of whom had degenerative changes on the foot. The other individual with a skeletal lesion had some new bone formation on the shaft of the right femur.

Among the individuals from the Spanish period samples, 41% had skeletal lesions. Four individuals, or 31% of those with skeletal lesions, had lesions due to degenerative changes on the joints. The most common site for skeletal lesions was the lower limbs, particularly among subadults. Skeletal lesions were more prevalent among females than males, and a higher prevalence was found among young adults than mid-adults.
Case Studies

Two individuals from the Spanish period burials exhibited an interesting pattern of skeletal lesions on the skull and the axial skeleton. Since the lesions found on these individuals were rather distinct, a differential diagnosis is can be undertaken compared to other individuals with more general lesions. These individuals are discussed here and a differential diagnosis of these two individuals is discussed in the next chapter.

Burial 2212

The individual from burial 2212 was a young adult female with several lesions on the frontal and occipital bones. Several erosive lesions were found on the endocranial and ectocranial surfaces of the frontal bone. On the ectocranial surface of the occipital bone, new bone formation with several radial scars was seen. The edges of the lytic lesions were smooth and had evidence of remodelling on the cortical bone. Remodelling of the spongy bone is also present which makes it unlikely for these lesions to be caused by insect activity or other taphonomic processes (Behrensmeyer 1978; Huchet et al. 2011; Backwell et al. 2012). The tibiae and fibulae of this individual were not examined since they were stored separately, having been excavated during a previous season. All the other skeletal elements from this individual were present, though most were fragmented. No lesions were found anywhere other than the skull and the vertebrae.
Figure 4.10. Diagrammatic representation of individual 2212 showing the bones present (gray) and bones with pathological lesions (black).
Figure 4.1. Erosive lesions on the ectocranial surface (top) and a close-up photo of the lesions (bottom) on the frontal bone of individual 2212 from Ille Cave. Photos taken by author.
Figure 4.12. Erosive lesions on the endocranial surface (top) and a close-up photo of the lesions (bottom) on the frontal bone of individual 2212 from Ille Cave. Photos taken by author.
Figure 4.13. Lesions on the ectocranial surface of the occipital bone of individual 2212 from Ille Cave. Photos taken by author.
Figure 4.14. Lesions on the endocranial surface of the occipital bone of individual 2212 from Ille Cave. Photos taken by author.
New bone formation and some lytic lesions on the vertebral body of a lumbar vertebra from burial 2212 were observed. No other lesions were found on other vertebrae, although most were fragmented which made it difficult to examine the presence of lesions.

Figure 4.15. New bone formation and lytic lesions on the lumbar body of individual 2212. Photo taken by author.
Burial 3

The individual from Burial 3 was recovered from the outlier pit in Ille Cave. This pit, which was located a few meters south of the west mouth trench, was excavated with the objective of avoiding possible burials in order to get to the lower levels more quickly. However, three burials were uncovered from the area, and one of these burials is burial 3, a young adult of unknown sex. This individual is represented by a fragmented cranium, several vertebrae, some rib fragments and some hand & foot bones. Several osteolytic lesions and some new bone formation on the vertebral bodies and vertebral ends of the ribs were observed in this individual. No other lesions were found in other bones from this individual, although burial 3 is represented only by the vertebrae, ribs, and some hand and foot bones.
Figure 4.16. Diagrammatic representation of individual 3 showing the bones present (gray) and bones with pathological lesions (black).
Figure 4.17. Osteolytic lesions on the left lateral bodies (upper left), right lateral bodies (upper right), and anterior bodies (bottom photos) of the thoracic vertebrae of individual 3. Photos taken by author.
Figure 4.18. Resorptive lesions on the vertebral ends of the ribs of individual 3 (top photos) and new bone formation on the lateral side of a thoracic body (bottom left) and on the costal tubercle of a rib (bottom right). Photo taken by author.
Oral Pathologies

This section examines the oral pathologies present on the individuals from the pre-colonial and Spanish period samples. The results are presented according to tooth type and according to the type of pathology.

Dental Census

As shown in Table 4.16, a total of 84 teeth from the pre-colonial burials and 362 teeth from the Spanish period burials were examined. All the teeth recorded from the pre-colonial burials were permanent teeth, while those from the Spanish period burials involved a mixture of deciduous and permanent dentition. From the Spanish period samples, 106 deciduous teeth and 256 permanent teeth were examined, with 183 of the permanent teeth belonging to adults and 73 permanent teeth belonging to subadults with mixed dentition. Among children, 8 had mixed dentition, seven of whom were less than 6 years of age during death and one over six years of age.

Table 4.15. Adult individuals with recorded dentition from both samples.

<table>
<thead>
<tr>
<th></th>
<th>Pre-colonial burials</th>
<th>Spanish period burials</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Adults</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>No. With teeth</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>% With teeth</td>
<td>70.59</td>
<td>66.67</td>
</tr>
</tbody>
</table>

Table 4.16. Number of teeth from both samples according to tooth type.

<table>
<thead>
<tr>
<th>Tooth type</th>
<th>Pre-colonial burials</th>
<th>Spanish period burials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Permanent</td>
<td>Deciduous</td>
</tr>
<tr>
<td>Incisors</td>
<td>17</td>
<td>46</td>
</tr>
<tr>
<td>Canines</td>
<td>9</td>
<td>17</td>
</tr>
<tr>
<td>Pre-molars</td>
<td>24</td>
<td>-</td>
</tr>
<tr>
<td>Molars</td>
<td>34</td>
<td>43</td>
</tr>
<tr>
<td>Total</td>
<td>84</td>
<td>106</td>
</tr>
</tbody>
</table>

Table 4.17. Subadult individuals with recorded teeth from the Spanish period samples.

<table>
<thead>
<tr>
<th></th>
<th>Spanish period burials</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Subadults</td>
<td>17</td>
</tr>
<tr>
<td>No. With teeth</td>
<td>11</td>
</tr>
<tr>
<td>% With teeth</td>
<td>64.71</td>
</tr>
<tr>
<td>No. With mixed dentition</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Deciduous</td>
</tr>
<tr>
<td>No. With teeth</td>
<td>11</td>
</tr>
<tr>
<td>No. Of teeth</td>
<td>106</td>
</tr>
</tbody>
</table>
Pre-colonial samples

Since the individuals from the pre-colonial sample exhibited only alveolar resorption and no other oral pathologies, only a comparison of alveolar resorption according to tooth type was accomplished. Two individuals from the sample, a young adult male and a mid-adult female, had alveolar resorption. The premolars were the most affected area overall, among young adults, mid-adults and females. Among males, the canines had the highest proportion of dental lesions. Lesions were most prevalent among young adults as seen in Table 4.18, and females were more affected by dental lesions overall than males. Overall, there was a statistically significant difference in the prevalence of oral lesions according to age but not according to sex.

Table 4.18. Distribution of alveolar resorption from the pre-colonial burials per tooth type according to age group. A – number of affected teeth, O – number of observed teeth.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Incisors A/O</th>
<th>Canines A/O</th>
<th>Pre-molars A/O</th>
<th>Molars A/O</th>
<th>Total A/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young adults</td>
<td>0/0</td>
<td>1/1</td>
<td>2/2</td>
<td>0/0</td>
<td>3/3</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>0/7</td>
<td>0/5</td>
<td>1/14</td>
<td>1/20</td>
<td>2/46</td>
</tr>
<tr>
<td>Unknown adults</td>
<td>0/10</td>
<td>0/3</td>
<td>0/8</td>
<td>0/14</td>
<td>0/35</td>
</tr>
<tr>
<td>Total</td>
<td>0/17</td>
<td>1/9</td>
<td>3/24</td>
<td>1/34</td>
<td>5/84</td>
</tr>
</tbody>
</table>

Young adults vs. Mid-adults Fisher’s exact test p-values

|          |          | 0.1667 | **0.0250** |          | **0.0005** |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference

Table 4.19. Distribution of alveolar resorption from the pre-colonial burials per tooth type according to sex.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Incisors A/O</th>
<th>Canines A/O</th>
<th>Pre-molars A/O</th>
<th>Molars A/O</th>
<th>Total A/O</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>0/7</td>
<td>1/6</td>
<td>2/13</td>
<td>0/16</td>
<td>3/42</td>
</tr>
<tr>
<td>Females</td>
<td>0/0</td>
<td>0/0</td>
<td>1/3</td>
<td>1/4</td>
<td>2/7</td>
</tr>
<tr>
<td>Unknown</td>
<td>0/10</td>
<td>0/3</td>
<td>0/8</td>
<td>0/14</td>
<td>0/35</td>
</tr>
<tr>
<td>Total</td>
<td>0/17</td>
<td>1/9</td>
<td>3/24</td>
<td>1/24</td>
<td>5/84</td>
</tr>
</tbody>
</table>

Males vs. Females Fisher’s exact test p-values

|          |          |          | 0.4893 | 0.2000 | 0.1430 |

Key: A – number of affected teeth, O – number of observed teeth
Spanish period samples

The old adults had the highest proportion of oral pathologies by teeth among all adult age groups; however the single individual identified as an old adult skewed the proportions of sample. The premolars were the most affected teeth overall among adults. The premolars were the most affected among young adults while the molars had the highest proportion of dental lesions among mid-adults. The single old adult exhibited dental lesions on all tooth types. Overall, the difference in prevalence of oral lesions according to adult age was statistically significant. The difference in prevalence of oral pathologies in the canines and pre-molars was also found to be statistically significant.
Among children, the incisors had the most lesions among permanent dentition while canines had higher proportions of dental lesions among deciduous dentition. Among the deciduous teeth of children, the canines had the highest proportion of dental lesions in those less than six years of age while the molars were the most affected in children over six years old. A similar pattern is seen in the permanent dentition of children, however the children over six years of age only had observable permanent canines and molars unlike children under six years where all tooth types were represented. On the whole, the children above six years of age had a higher proportion of oral lesions on both deciduous and permanent dentition than those less than six years. The overall difference in prevalence of dental lesions was not statistically significant, though the difference in prevalence of lesions in the molars for both deciduous and permanent dentition was statistically significant.

Overall, females had a higher proportion of oral lesions than males. Among males, the molars had the highest proportion of teeth with dental lesions while pre-molars were most affected among females. The difference in prevalence of oral lesions between males and females was statistically significant overall and on all tooth types.

Table 4.20. Distribution of pathologies from the Spanish period burials per tooth type according to adult age group.

<table>
<thead>
<tr>
<th>Age (adults)</th>
<th>Incisors</th>
<th>Canines</th>
<th>Pre-molars</th>
<th>Molars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
</tr>
<tr>
<td>Young adults</td>
<td>17/23</td>
<td>12/14</td>
<td>21/23</td>
<td>19/30</td>
<td>69/90</td>
</tr>
<tr>
<td></td>
<td>73.91%</td>
<td>85.71%</td>
<td>91.30%</td>
<td>63.33%</td>
<td>76.67%</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>16/24</td>
<td>3/10</td>
<td>9/19</td>
<td>17/24</td>
<td>45/77</td>
</tr>
<tr>
<td></td>
<td>66.67%</td>
<td>30%</td>
<td>47.37%</td>
<td>70.83%</td>
<td>58.44%</td>
</tr>
<tr>
<td>Old adults</td>
<td>4/4</td>
<td>2/2</td>
<td>4/4</td>
<td>6/6</td>
<td>16/16</td>
</tr>
<tr>
<td></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Total</td>
<td>37/51</td>
<td>17/26</td>
<td>34/46</td>
<td>42/60</td>
<td>130/183</td>
</tr>
<tr>
<td></td>
<td>72.55%</td>
<td>65.38%</td>
<td>73.91%</td>
<td>70%</td>
<td>71.04%</td>
</tr>
</tbody>
</table>

Chi square test p-values

|               | 0.3768 | 0.0186* | 0.0025 | 0.2005 | 0.0010 |

Key: A – number of affected teeth, O – number of observed teeth. P-values in bold indicates a statistically significant difference, * - mid-adults and old adult samples were combined to produce valid values for statistical comparison.
Table 4.2. Distribution of pathologies from the Spanish period burials per tooth type according to subadult age group.

<table>
<thead>
<tr>
<th>Age (subadults)</th>
<th>Deciduous dentition</th>
<th>Permanent dentition</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I A/O (%)</td>
<td>C A/O (%)</td>
</tr>
<tr>
<td>&lt;6 years</td>
<td>4/42 (9.52%)</td>
<td>4/16 (25%)</td>
</tr>
<tr>
<td>&gt;6 years</td>
<td>0/4 (0%)</td>
<td>0/1 (0%)</td>
</tr>
<tr>
<td>Total</td>
<td>4/46 (8.70%)</td>
<td>4/17 (23.53%)</td>
</tr>
</tbody>
</table>

<6 years vs. >6 years Fisher’s exact test p-values

|                  | 1.0000 | 1.0000 | **0.0399** | 0.1193 | - | 0.1667 | - | **0.0005** | 0.1346 |

Key: I – incisors, C – canines, Pm – premolars, M – molars, A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference

Table 4.22. Distribution of pathologies from the Spanish period burials per tooth type according to sex

<table>
<thead>
<tr>
<th>Sex</th>
<th>Incisors A/O %</th>
<th>Canines A/O %</th>
<th>Pre-molars A/O %</th>
<th>Molars A/O %</th>
<th>Total A/O %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>20/33 (60.61%)</td>
<td>7/15 (46.67%)</td>
<td>18/30 (60%)</td>
<td>25/41 (60.98%)</td>
<td>70/119 (58.82%)</td>
</tr>
<tr>
<td>Females</td>
<td>17/18 (94.44%)</td>
<td>10/11 (90.91%)</td>
<td>16/16 (100%)</td>
<td>17/19 (89.47%)</td>
<td>60/64 (93.75%)</td>
</tr>
<tr>
<td>Total</td>
<td>37/51 (72.55%)</td>
<td>17/26 (65.38%)</td>
<td>34/46 (73.91%)</td>
<td>42/60 (70%)</td>
<td>130/183 (71.04%)</td>
</tr>
</tbody>
</table>

Males vs. Females Fisher’s exact test p-values

|                  | 0.0101 | 0.0362 | **0.0035** | **0.0340** | P<0.0001 |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference

Figure 4.21. The distribution of permanent teeth with oral pathologies from the Spanish period samples according to age.
Caries

Overall, incisors had the highest percentage of teeth affected with caries compared to all other tooth types among adults. The highest proportion of caries was found among mid-adults compared to all other age groups. The canines had the highest proportion of caries among mid-adults followed by the molars. Among young adults, the incisors had the highest prevalence of caries among all teeth with dental lesions followed by canines. Only the deciduous dentition had evidence of caries among children. The molars had the highest proportion of caries among the deciduous dentition both for individuals below six years of age and those over six years. Females had a higher prevalence of caries than males, though the difference is very little. Among males, caries was more commonly found on molars while the incisors had the highest proportion of teeth with caries in females. The overall difference in
prevalence of caries according to both adult and subadult age was statistically significant, as is the difference in caries prevalence on the molars. However, no statistically significant difference on the prevalence of caries according to sex was found. Tables 4.23 and 4.24 show the distribution of caries according to age while Table 4.25 shows the distribution according to sex.

The caries correction factor is a method of calibrating the caries rates which takes into account the teeth that were lost antemortem and by estimating the number of teeth lost due to caries (Lukacs 1995; Erdal and Duyar 1999). It is calculated by looking at the estimated number of teeth lost due to caries, the total estimated number of teeth with caries, the total number of original teeth and the number of teeth lost antemortem (Lukacs 1995; Erdal and Duyar 1999). The caries corrected factor has been applied to several samples from mainland Southeast Asia (Domett 2001; Domett 2004; Tayles et al. 2007) to obtain a more accurate result. However, these correction procedures “make assumptions that are difficult to test” (Hillson 2001, p.257) and does not necessarily produce more precise results (Hillson 2001; Oxenham et al. 2006). The caries correction factor cannot be applied to the samples from both the pre-colonial and Spanish period due to the preservation of the dental remains. The teeth found with the skeletal remains from these sites are mainly loose teeth with the maxillary and mandibular bones usually in a fragmented state. Thus, the number of teeth lost antemortem cannot be observed for most of the individuals in the sample which makes the application of the caries correction factor impossible.

Table 4.23. Distribution of caries from the Spanish period burials per tooth type according to adult age group.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Incisors A/O</th>
<th>Incisors %</th>
<th>Canines A/O</th>
<th>Canines %</th>
<th>Pre-molars A/O</th>
<th>Pre-molars %</th>
<th>Molars A/O</th>
<th>Molars %</th>
<th>Total A/O</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-adults</td>
<td>7/24</td>
<td>29.17</td>
<td>1/10</td>
<td>10</td>
<td>4/19</td>
<td>21.05</td>
<td>10/24</td>
<td>41.67</td>
<td>22/77</td>
<td>28.57</td>
</tr>
<tr>
<td>Old adults</td>
<td>0/4</td>
<td>0</td>
<td>0/2</td>
<td>0</td>
<td>0/4</td>
<td>0</td>
<td>0/6</td>
<td>0</td>
<td>0/16</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>14/51</td>
<td>27.45</td>
<td>5/26</td>
<td>19.23</td>
<td>8/46</td>
<td>17.39</td>
<td>15/60</td>
<td>25</td>
<td>42/183</td>
<td>22.95</td>
</tr>
</tbody>
</table>

Chi square test p-values

| A/O | 0.4378 | 0.1918* | 1.0000* | 0.0357 | 0.0458 |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference, * - mid-adults and old adult samples were combined to produce valid values for statistical comparison
Table 4.2. Distribution of caries from the Spanish period burials per tooth type according to subadult age group. Only deciduous dentition is shown since no permanent dentition had evidence of caries.

<table>
<thead>
<tr>
<th>Age (subadults)</th>
<th>Incisors</th>
<th>Canines</th>
<th>Molars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
<td>%</td>
</tr>
<tr>
<td>&lt;6 years</td>
<td>0/42</td>
<td>0</td>
<td>2/16</td>
<td>12.5</td>
</tr>
<tr>
<td>&gt;6 years</td>
<td>0/4</td>
<td>0</td>
<td>0/1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>0/46</td>
<td>0</td>
<td>2/17</td>
<td>11.76</td>
</tr>
</tbody>
</table>

<6 years vs. >6 years Fisher’s exact test p-values

|             | 1.0000 | 0.0153 | 0.0141 |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference

Table 4.25. Distribution of caries from the Spanish period burials per tooth type according to sex.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Incisors</th>
<th>Canines</th>
<th>Pre-molars</th>
<th>Molars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
</tr>
<tr>
<td>Females</td>
<td>7/18</td>
<td>38.89</td>
<td>4/11</td>
<td>36.36</td>
<td>4/16</td>
</tr>
<tr>
<td>Total</td>
<td>14/51</td>
<td>27.45</td>
<td>5/26</td>
<td>19.23</td>
<td>8/46</td>
</tr>
</tbody>
</table>

Males vs. Females Fisher’s exact test p-values

|             | 0.2037 | 0.1279 | 0.4211 | 1.0000 | 0.0650 |

Key: A – number of affected teeth, O – number of observed teeth

Figure 4.24. Some examples of caries from the Spanish period burials. The photo on the left shows caries on the left maxillary teeth of individual 23, a subadult from Sibaltan. The photo on the right shows large carious lesions on the cemento-enamel junction of the mandibular teeth of individual 21, a young adult female from Sibaltan. Photos taken by author.

Calculus

The overall prevalence of calculus among the Spanish period samples was low. As shown in Tables 4.26 and 4.27, calculus was found only among mid-adults, old adults and males from the sample. The incisors had the highest proportion of teeth with calculus overall and among mid-adults, old adults and males. The overall difference in the prevalence of calculus according to adult age was statistically significant, as well as the difference in
prevalence on the incisors, pre-molars and molars. The overall difference in prevalence of calculus according to sex was also statistically significant, though the differences in all tooth types are not.

Table 4.26. Distribution of calculus from the Spanish period burials per tooth type according to adult age group.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Incisors</th>
<th>Canines</th>
<th>Pre-molars</th>
<th>Molars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
</tr>
<tr>
<td>Young adults</td>
<td>0/23</td>
<td>0/14</td>
<td>0/23</td>
<td>0/30</td>
<td>0/90</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>2/24</td>
<td>0/10</td>
<td>1/19</td>
<td>1/24</td>
<td>3/77</td>
</tr>
<tr>
<td>Old adults</td>
<td>4/4</td>
<td>2/2</td>
<td>4/4</td>
<td>5/6</td>
<td>15/16</td>
</tr>
<tr>
<td>Total</td>
<td>6/51</td>
<td>2/26</td>
<td>5/46</td>
<td>6/60</td>
<td>19/183</td>
</tr>
</tbody>
</table>

Chi square test p-values*  

|               | 0.0181* | 0.1119* | 0.0179* | 0.0098* | P<0.0001 |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference, * - mid-adults and old adult samples were combined to produce valid values for statistical comparison

Table 4.27. Distribution of calculus from the Spanish period burials per tooth type according to sex.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Incisors</th>
<th>Canines</th>
<th>Pre-molars</th>
<th>Molars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
</tr>
<tr>
<td>Males</td>
<td>6/33</td>
<td>0/11</td>
<td>5/30</td>
<td>6/41</td>
<td>19/119</td>
</tr>
<tr>
<td>Females</td>
<td>0/18</td>
<td>2/15</td>
<td>0/16</td>
<td>0/19</td>
<td>0/64</td>
</tr>
<tr>
<td>Total</td>
<td>6/51</td>
<td>2/26</td>
<td>5/46</td>
<td>6/60</td>
<td>19/183</td>
</tr>
</tbody>
</table>

Males vs. Females Fisher’s exact test p-values

|               | 0.0782   | 0.4923  | 0.1470     | 0.1634 | 0.0002 |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference

Periapical lesions

As seen in Tables 4.28 and 4.29, the prevalence of periapical lesions among the Spanish period samples was very low. The lesions were found only among young adults and were more common among females than males. The canines were the most common site for periapical lesions among young adults and males while the incisors had a higher proportion of periapical lesions among females. The overall difference in the prevalence of periapical lesions according to adult age was statistically significant, whilst the differences observed according to sex was not.
Table 4.2. Distribution of periapical lesions from the Spanish period burials per tooth type according to adult age group.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Incisors A/O</th>
<th>Canines A/O</th>
<th>Pre-molars A/O</th>
<th>Molars A/O</th>
<th>Total A/O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Young adults</td>
<td>2/23 8.70</td>
<td>2/14 14.29</td>
<td>1/23 4.35</td>
<td>0/30 0</td>
<td>5/90 5.55</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>0/24 0</td>
<td>0/10 0</td>
<td>0/19 0</td>
<td>0/24 0</td>
<td>0/77 0</td>
</tr>
<tr>
<td>Old adults</td>
<td>0/4 0</td>
<td>0/2 0</td>
<td>0/4 0</td>
<td>0/6 0</td>
<td>0/16 0</td>
</tr>
<tr>
<td>Total</td>
<td>2/51 3.92</td>
<td>2/26 7.69</td>
<td>1/46 2.17</td>
<td>0/60 0</td>
<td>5/183 2.73</td>
</tr>
</tbody>
</table>

Fisher’s exact test p-values*  
|                      | 0.1984 | 0.4831 | 1.0000 | -        | 0.0272    |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference, * - mid-adults and old adult samples were combined to produce valid values for statistical comparison

Table 4.29. Distribution of periapical lesions from the Spanish period burials per tooth type according to sex.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Incisors A/O</th>
<th>Canines A/O</th>
<th>Pre-molars A/O</th>
<th>Molars A/O</th>
<th>Total A/O</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td></td>
</tr>
<tr>
<td>Males</td>
<td>0/33 0</td>
<td>1/15 6.67</td>
<td>1/30 3.33</td>
<td>0/41 0</td>
<td>2/119 1.68</td>
</tr>
<tr>
<td>Females</td>
<td>2/18 11.11</td>
<td>1/11 9.09</td>
<td>0/16 0</td>
<td>0/19 0</td>
<td>3/64 4.69</td>
</tr>
<tr>
<td>Total</td>
<td>2/51 3.92</td>
<td>2/26 7.69</td>
<td>1/46 2.17</td>
<td>0/60 0</td>
<td>5/183 2.73</td>
</tr>
</tbody>
</table>

Males vs. Females Fisher’s exact test p-values  
|                      | 0.1200 | 1.0000 | 1.0000 | -        | 0.3450    |

Key: A – number of affected teeth, O – number of observed teeth

Figure 4.25. Periapical lesion on the maxilla of individual 2212, a young adult female from Ille Cave. Photos taken by author.
Alveolar Resorption

The prevalence of alveolar resorption among the Spanish period individuals was quite high. The single old adult individual showed signs of alveolar resorption, thus skewing the proportion. However, young adults had a higher proportion of teeth with alveolar resorption than mid-adults. Overall, alveolar resorption was most commonly found near the molars in adults and near the incisors in subadults. Among subadults, children over six years of age had a higher proportion of alveolar resorption prevalence than those below six years of age, though resorption was present only on the molars. Males had a higher prevalence of alveolar resorption compared to females, and resorption was more prevalent near the canines for males and the molars for females. The difference in prevalence of alveolar resorption was statistically significant overall and in all tooth sockets except the canines. Among subadults, only the difference in prevalence of alveolar resorption in the molar region was statistically significant. The overall difference in the prevalence between males and females was statistically significant, as is the difference in prevalence in the molar region.

Table 4.30. Distribution of alveolar resorption from the Spanish period burials per tooth type according to adult age group.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Incisors A/O</th>
<th>Incisors %</th>
<th>Canines A/O</th>
<th>Canines %</th>
<th>Pre-molars A/O</th>
<th>Pre-molars %</th>
<th>Molars A/O</th>
<th>Molars %</th>
<th>Total A/O</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Young adults</td>
<td>12/23</td>
<td>52.17</td>
<td>8/14</td>
<td>57.14</td>
<td>16/23</td>
<td>69.57</td>
<td>17/30</td>
<td>56.67</td>
<td>53/90</td>
<td>58.89</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>7/24</td>
<td>29.17</td>
<td>2/10</td>
<td>20</td>
<td>5/19</td>
<td>26.32</td>
<td>10/24</td>
<td>41.67</td>
<td>24/77</td>
<td>31.17</td>
</tr>
<tr>
<td>Old adults</td>
<td>4/4</td>
<td>100</td>
<td>2/2</td>
<td>100</td>
<td>4/4</td>
<td>100</td>
<td>6/6</td>
<td>100</td>
<td>16/16</td>
<td>100</td>
</tr>
<tr>
<td>Total</td>
<td>23/51</td>
<td>45.10</td>
<td>12/26</td>
<td>46.15</td>
<td>25/46</td>
<td>54.35</td>
<td>33/60</td>
<td>55</td>
<td>93/183</td>
<td>50.82</td>
</tr>
</tbody>
</table>

Chi square test p-values

|                | 0.0203 | 0.1025* | 0.0031 | 0.0357 | P<0.0001 |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference, * - mid-adults and old adult samples were combined to produce valid values for statistical comparison

Table 4.31. Distribution of alveolar resorption from the Spanish period burials per tooth type according to subadult age group.

<table>
<thead>
<tr>
<th>Age (subadults)</th>
<th>Incisors A/O</th>
<th>Incisors %</th>
<th>Canines A/O</th>
<th>Canines %</th>
<th>Molars A/O</th>
<th>Molars %</th>
<th>Total A/O</th>
<th>Total %</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;6 years</td>
<td>4/42</td>
<td>9.52</td>
<td>2/16</td>
<td>12.5</td>
<td>2/36</td>
<td>5.55</td>
<td>8/94</td>
<td>8.51</td>
</tr>
<tr>
<td>&gt;6 years</td>
<td>0/4</td>
<td>0</td>
<td>0/1</td>
<td>0</td>
<td>3/7</td>
<td>42.86</td>
<td>3/12</td>
<td>25</td>
</tr>
<tr>
<td>Total</td>
<td>4/46</td>
<td>8.70</td>
<td>2/17</td>
<td>11.76</td>
<td>5/43</td>
<td>11.63</td>
<td>11/106</td>
<td>10.38</td>
</tr>
</tbody>
</table>

<6 years vs. >6 years Fisher’s exact test p-values

|                | 1.0000 | 1.0000 | 0.0242 | 0.1088 |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference
Table 4.3. Distribution of alveolar resorption from the Spanish period burials per tooth type according to sex.

<table>
<thead>
<tr>
<th>Sex</th>
<th>Incisors</th>
<th>Canines</th>
<th>Pre-molars</th>
<th>Molars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
</tr>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>Males</td>
<td>15/33</td>
<td>6/15</td>
<td>13/30</td>
<td>18/41</td>
<td>52/119</td>
</tr>
<tr>
<td></td>
<td>45.45</td>
<td>40</td>
<td>43.33</td>
<td>43.90</td>
<td>43.70</td>
</tr>
<tr>
<td>Females</td>
<td>8/18</td>
<td>6/11</td>
<td>12/16</td>
<td>15/19</td>
<td>41/64</td>
</tr>
<tr>
<td></td>
<td>44.44</td>
<td>54.55</td>
<td>75</td>
<td>78.95</td>
<td>64.06</td>
</tr>
<tr>
<td>Total</td>
<td>23/51</td>
<td>12/26</td>
<td>25/46</td>
<td>33/60</td>
<td>93/183</td>
</tr>
<tr>
<td></td>
<td>45.10</td>
<td>46.15</td>
<td>54.35</td>
<td>55</td>
<td>50.82</td>
</tr>
</tbody>
</table>

Males vs. Females Fisher’s exact test p-values

<table>
<thead>
<tr>
<th></th>
<th>1.0000</th>
<th>0.6922</th>
<th>0.0625</th>
<th><strong>0.0135</strong></th>
<th><strong>0.0128</strong></th>
</tr>
</thead>
</table>

Key: A – number of affected teeth, O – number of observed teeth, P-values in **bold** indicates a statistically significant difference.

Figure 4.26. Alveolar resorption on the mandible of individual 21 (top), a young adult female from Sibaltan, and on the maxilla of individual 2 (bottom), an old adult male from Bongabong. Top photo taken by author, bottom photo from Ang et al. (2011)
Summary of Oral Pathologies in the samples

The prevalence of oral pathologies in the pre-colonial sample was very low, with only a few individuals having alveolar resorption. No other pathology was found among the pre-colonial sample apart from alveolar resorption.

In the Spanish period samples, a diverse variety of oral pathologies were found. Alveolar resorption and dental caries were among the most prevalent pathologies in adults while linear enamel hypoplasia was most common among children. Linear enamel hypoplasia is discussed in the following section. While alveolar resorption was most prevalent among old adults, caries was more common among mid-adults and LEH in children was found only among those less than six years of age. Overall, oral pathologies were more prevalent in females than males.

Non-specific indicators of stress

Non-specific indicators of stress were found only among the individuals from the Spanish period. Cribra orbitalia and linear enamel hypoplasia from these individuals were examined and recorded.

Cribra orbitalia

Two individuals, both of whom were young adult females, had evidence of cribra orbitalia. In both of these individuals, cribra orbitalia was remodelled, suggesting a recovery from stress. Figure 4.27 shows the cribra orbitalia from both individuals.

![Figure 4.27. Cribra orbitalia on the left orbit of individual 800 from Ile Cave (left) and on the right orbit of individual 21 from Sibaltan (right). Photos taken by author.](image)
Linear Enamel Hypoplasia (LEH)

Among adults, linear enamel hypoplasia was found only in one young adult female. A higher proportion of LEH was found on canines and pre-molars compared to any other tooth type as shown in Table 4.33. Among subadults, three individuals, all of whom were under six years of age had LEH. The difference in prevalence of LEH according to adult age and sex was statistically significant overall and on all tooth types. The total difference in prevalence of LEH among subadults below and above six years of age was also statistically significant. However, the difference in prevalence according to each tooth type was not statistically significant. Figure 4.28 shows examples of LEH among the individuals from the Spanish period samples.

Table 4.33. Distribution of linear enamel hypoplasia from the Spanish period burials per tooth type according to adult age group.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Incisors</th>
<th>Canines</th>
<th>Pre-molars</th>
<th>Molars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
</tr>
<tr>
<td>Young adults</td>
<td>8/23 34.78</td>
<td>4/14 28.57</td>
<td>8/23 34.78</td>
<td>9/30 30</td>
<td>29/90 32.22</td>
</tr>
<tr>
<td>Mid-adults</td>
<td>0/24 0</td>
<td>0/10 0</td>
<td>0/19 0</td>
<td>0/24 0</td>
<td>0/77 0</td>
</tr>
<tr>
<td>Old adults</td>
<td>0/4 0</td>
<td>0/2 0</td>
<td>0/4 0</td>
<td>0/6 0</td>
<td>0/16 0</td>
</tr>
<tr>
<td>Total</td>
<td>8/51 15.69</td>
<td>4/26 15.38</td>
<td>8/46 17.39</td>
<td>9/60 15</td>
<td>29/183 15.85</td>
</tr>
</tbody>
</table>

Chi square test p-values

|                | 0.0007* | 0.0441* | 0.0019* | 0.0011* | P<0.0001 |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference, * - mid-adults and old adult samples were combined to produce valid values for statistical comparison

Table 4.34. Distribution of linear enamel hypoplasia from the Spanish period burials per tooth type according to subadult age group. Only permanent dentition (unerupted and erupted) is shown since no deciduous dentition had evidence of LEH.

<table>
<thead>
<tr>
<th>Age (subadults)</th>
<th>Incisors</th>
<th>Canines</th>
<th>Pre-molars</th>
<th>Molars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
<td>%</td>
<td>A/O</td>
</tr>
<tr>
<td>&lt;6 years</td>
<td>14/20 70</td>
<td>5/7 71.43</td>
<td>3/8 37.5</td>
<td>6/30 20</td>
<td>28/65 43.08</td>
</tr>
<tr>
<td>&gt;6 years</td>
<td>0/0 0</td>
<td>0/2 0</td>
<td>0/0 0</td>
<td>0/6 0</td>
<td>0/8 0</td>
</tr>
<tr>
<td>Total</td>
<td>14/20 70</td>
<td>5/9 55.55</td>
<td>3/8 37.5</td>
<td>6/36 16.67</td>
<td>28/73 38.36</td>
</tr>
</tbody>
</table>

<6 years vs. >6 years Fisher’s exact test p-values

|                | 0.1667 | 0.5610 | 0.0202 |

Key: A – number of affected teeth, O – number of observed teeth, P-values in bold indicates a statistically significant difference

169
Table 4.3. Distribution of linear enamel hypoplasia from the Spanish period burials per tooth type according to sex.

<table>
<thead>
<tr>
<th></th>
<th>Incisors</th>
<th>Canines</th>
<th>Pre-molars</th>
<th>Molars</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
<td>A/O</td>
</tr>
<tr>
<td>Males</td>
<td>0/33 0</td>
<td>0/15 0</td>
<td>0/30 0</td>
<td>0/41 0</td>
<td>0/119 0</td>
</tr>
<tr>
<td>Females</td>
<td>8/18 44.44</td>
<td>4/11 36.36</td>
<td>8/16 50</td>
<td>9/19 47.37</td>
<td>29/64 45.31</td>
</tr>
<tr>
<td>Total</td>
<td>8/51 15.69</td>
<td>4/26 15.38</td>
<td>8/46 17.39</td>
<td>9/60 15</td>
<td>29/183 15.85</td>
</tr>
</tbody>
</table>

Males vs. Females Fisher’s exact test p-values

<table>
<thead>
<tr>
<th></th>
<th>P&lt;0.0001</th>
<th>0.0221</th>
<th>P&lt;0.0001</th>
<th>P&lt;0.0001</th>
<th>P&lt;0.0001</th>
</tr>
</thead>
</table>

Key: A – number of affected teeth, O – number of observed teeth, P-values in **bold** indicates a statistically significant difference.
Figure 4.2. Linear enamel hypoplasia on the left central maxillary incisors of individual 2212 (top left) and individual 224 (top right), the right maxillary canine of individual 765 (bottom left) and on the left lateral mandibular incisor of individual 2255 (bottom right). All are subadults under 6 years of age. Photos taken by author.
Chapter Summary

This chapter has presented the results of the examination of the skeletal samples from two different time periods in the Philippines. Overall, both skeletal and oral pathologies were more prevalent among the Spanish period samples compared to the pre-colonial samples. A discussion of these results within the regional and temporal context is discussed in the next chapter.
Chapter 5 – DISCUSSION AND CONCLUSION

This chapter presents a summary and comparison of the skeletal and oral pathologies from both the pre-colonial and Spanish period samples. A differential diagnosis of the two individuals with distinct skeletal lesions is discussed in this chapter. How the aims of this thesis have been achieved is also presented in this chapter.

Summary of Results

This section presents a summary and comparison of the distribution of the individuals from the pre-colonial and Spanish period burials according to age and sex. Comparisons of the patterns of skeletal and oral pathologies according to age and sex are also discussed.

The Samples

There are more individuals from the Spanish period burials than the pre-colonial burials. The individuals from the pre-colonial burials had an uneven distribution according to sex, where more males were present and only a single female was found. An even distribution of males and females was seen in the individuals from the Spanish period burials. However, few individuals were identified as males and females from both samples due to poor preservation of the individuals from the pre-colonial sample and a high number of subadults in the Spanish period samples.

Preservation of Skeletal Remains

Most of the skeletal remains from both samples were fragmented. The bones of the skull, vertebrae and pelvic bones were usually fragmented into several little pieces which made assessment of age and sex difficult. Some individuals had skulls and long bones which had been previously reconstructed. A higher proportion of individuals with nearly complete skeletal remains were found in the Spanish period burials, with 44% of the individuals represented by almost complete remains compared to only 17% of the individuals from the pre-colonial sample. Most of the individuals represented by very few skeletal remains were from the pre-colonial burials, with 67% of individuals having very poor preservation in comparison to 34% of the individuals from the Spanish period samples. Also, as noted by a previous researcher who examined the skeletal remains from the pre-colonial burials (Shaw...
most of the remains were covered with a cement-like layer of sand which made visual examination difficult. This layer is difficult to remove without damaging the surface of the bone, thus close-up observations of cortical bone for evidence of disease and trauma were impossible to carry out.

All of the individuals from the Spanish period sites were extended burials while those from the pre-colonial sites were mainly jar burials. Skeletal remains from jar burials in the Philippines tend to be poorly preserved; in some cases, no human remains were found inside the jars (Solheim 1951; Solheim 1954; Solheim 1964; Dizon 1979b; Dizon 1979c; Dizon 1979a). The high acidity of the soil in which the jar burials were buried were commonly cited as the reason for the poor preservation of remains (Dizon 1979b; Dizon 1979c; Dizon 1979a), although it is uncertain as to whether this is the case for the burials from Catnauan.

Skeletal Pathologies

The individuals from the pre-colonial burials had very little skeletal pathology – only three individuals, all of whom were male, exhibited any form of lesion. The lack of skeletal lesions from the pre-colonial burials may be attributed to the preservation of the skeletal remains from the sample which made the examination of any possible lesions on bone surfaces virtually impossible.

A higher proportion of individuals from the Spanish period burials had skeletal lesions compared to the pre-colonial sample. Skeletal lesions were more prevalent among adults than subadults, and lesions on the lower limbs were most common for both subadults and adults in the sample. However, nearly half of the subadults had skeletal lesions.

As seen in Figure 5.1, individuals from the Spanish period burials had skeletal lesions from all regions of the body while the pre-colonial individuals only had lesions on the lower limbs. Very few individuals from the pre-colonial sample had skeletal lesions compared to the Spanish period individuals, though the difference was not statistically significant (Fisher’s exact test p-value = 0.0673). In the pre-colonial sample, only males had skeletal lesions whereas both males and females had lesions in the Spanish period sample, with females having a slightly higher proportion of lesions than males.
Table 5.1. Location of skeletal lesions from the pre-colonial and Spanish period individuals.

<table>
<thead>
<tr>
<th>Location of lesions</th>
<th>Pre-colonial sample A/O (%)</th>
<th>Spanish Period sample A/O (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cranial</td>
<td>0/13 (0)</td>
<td>3/9 (33.33)</td>
</tr>
<tr>
<td>Vertebral</td>
<td>0/3 (0)</td>
<td>4/12 (33.33)</td>
</tr>
<tr>
<td>Axial</td>
<td>0/8 (0)</td>
<td>2/12 (16.67)</td>
</tr>
<tr>
<td>Upper limbs</td>
<td>0/13 (0)</td>
<td>3/12 (25)</td>
</tr>
<tr>
<td>Lower limbs</td>
<td>3/14 (21.43)</td>
<td>4/11 (36.37)</td>
</tr>
</tbody>
</table>

Key: A – affected individuals, O – individuals with observed skeletal elements.

![Figure 5.1. Comparison of the distribution of skeletal lesions from both samples.](image)

**Oral Pathologies**

Like the prevalence of skeletal pathologies in the pre-colonial individuals, oral pathologies were also very few. Only alveolar resorption was found in two individuals from the pre-colonial sample, although a previous study on the sample mentioned the presence of caries along with alveolar resorption (Shaw 2009). However, the previous research had included dental remains from non-burial contexts which were not done for this study.

The individuals from the Spanish period samples exhibited a variety of oral pathologies. Caries, calculus, periapical lesions and alveolar resorption were observed among adults while only caries and alveolar resorption were seen in subadults.

Figure 5.4 shows the differences in prevalence of oral pathologies between the two samples. Only adults were compared since no oral pathology affected the single adolescent from the pre-colonial sample. Only the prevalence of alveolar resorption between the two samples are comparable since only alveolar resorption was present in the pre-colonial sample. The proportion of individuals with resorption within the two samples was markedly different.
The difference in the prevalence of oral pathologies by tooth count between the two samples was statistically significant (Fisher’s exact test p-value = <0.0001).

Table 5.2. Oral pathologies of adult teeth from the pre-colonial and Spanish period samples.

<table>
<thead>
<tr>
<th>Oral Pathologies</th>
<th>Pre-colonial sample A/O (%)</th>
<th>Spanish Period Sample A/O (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caries</td>
<td>0/84 (0)</td>
<td>42/183 (22.95)</td>
</tr>
<tr>
<td>Calculus</td>
<td>0/84 (0)</td>
<td>19/183 (10.38)</td>
</tr>
<tr>
<td>Periapical lesions</td>
<td>0/84 (0)</td>
<td>5/183 (2.73)</td>
</tr>
<tr>
<td>Alveolar resorption</td>
<td>5/84 (5.95)</td>
<td>93/183 (50.81)</td>
</tr>
</tbody>
</table>

Key: A – number of affected teeth, O – number of observed teeth.

Figure 5.2. Distribution of oral pathologies of adult individuals from the pre-colonial and Spanish period samples.

Case Studies

Two individuals were discussed separately in the previous chapter due to the distinct nature of skeletal lesions found on these individuals. A differential diagnosis of the possible aetiologies of these lesions is presented here.

Burial 2212

The combination of bone resorption and new bone formation on the frontal and occipital bones of individual 2212 suggests the presence of some form of disease affecting the bone. Different diseases which leave lesions on the skull include a variety of infections such as osteomyelitis, tuberculosis and treponematosis, or some form of tumor. These diseases produce lytic lesions due to the destruction of bone during infection or the proliferation of tumor cells which leads to the destruction of cortical bone (Hackett 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Waldron 2009).
Neoplasms or tumors are characterized by the formation of clustered pits which are more evident on the endocranium than the ectocranium (Hackett 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). Multiple or large single perforations due to the destruction of the clustered pits are also characteristic of lesions due to tumors (Hackett 1976). Very little or no new bone formation is seen among individuals with lesions due to neoplasms (Hackett 1976). Extensive new bone formation was found on the occipital bone of individual 2212, and lesions are more pronounced on the ectocranial surface which makes it unlikely for these lesions to be formed due to tumors.

Evidence of tuberculosis is most commonly found on the vertebrae, although few individuals with tuberculosis also had lesions on the skull, particularly younger children (Hackett 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). A round lytic lesion with a “moth-eaten central sequestrum” (Ortner 2003, p.248) is characteristic of tuberculosis (Hackett 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). These lesions are often localized and changes are more marked in the inner surface than the outer surface of the skull (Hackett 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). The lesions found on individual 2212 are rather extensive and are more evident on the ectocranial surface which also makes it unlikely to be due to tuberculosis.

Osteomyelitis of the skull is rather rare, and the frontal and parietal areas are the most commonly affected and no lesions are usually seen on the occipital bone (Hackett 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). Lytic lesions on the affected area are common with new bone formation usually surrounding the affected area (Hackett 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). The range of variation of lesions due to osteomyelitis is huge, with some having localized lesions while others have lesions affecting most of the skull (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). However no caries sicca sequence has been found among individuals with osteomyelitis of the skull (Hackett 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). The lesions found on individual 2212 are similar to the caries sicca formation sequence described by Hackett (1976), which makes it unlikely for these lesions to be due to osteomyelitis.
As discussed in Chapter 3, the skeletal lesions caused by treponemal disease are most commonly found on the tibiae and the skull. Based on the skeletal lesions found on the skull of individual 2212, particularly the distinct radial scarring on the occipital bone, it is highly possible that this individual suffered from some form of treponemal disease, most probably syphilis. The sequence of the formation of caries sicca, the main diagnostic criterion of syphilis, had been described in detail by Hackett (1976). Three series of caries sicca sequence on the cranium were identified: the initial, discrete and contiguous series (Hackett 1976). The initial series forms the first stages of caries sicca development and is characterized by the formation of well-defined clustered pits and confluent clustered pits usually on the outer surface of the calvarium (Hackett 1976). These pits are usually found on the frontal and parietal bones of the skull (Hackett 1976). The discrete series is marked by the superficial cavitation of the clustered pits and the start of new bone formation, radial scarring and bone remodelling (Hackett 1976). The contiguous series is marked by serpiginous cavitation or the clustering of pits due to bone destruction, nodular cavitation or the remodelling of the sharp margins of clustered cavities and caries sicca, the enlargement of nodules due to bone remodelling of the margins of the pits (Hackett 1976). The frontal bone of individual 2212 displayed some clustered pits on the endocranial surface and confluence pits and perforations on the ectocranial surface which suggests that the individual was at the initial series stage of caries sicca development. Also, more lesions are seen on the ectocranial surface than the endocranium which is also characteristic of syphilis (Hackett 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). The radial scarring and bone remodelling on the occipital bone is typical of the discrete series of caries sicca development where the rimmed margin of the pits has already flattened. The thickening of the endocranial surface of the occipital bone due to organized new bone deposition (Hackett 1976, p.41) was
also present. The distinct pattern of pitting and radial scarring found on the frontal and occipital bones of this individual makes it extremely likely that this person suffered from treponemal disease rather than any of the other diseases.

**Figure 5.4. Syphilis sequence of the cranium. Drawings from Hackett (1976, p.31, 42).**

It is unknown as to what caused the bone formation and lytic lesions on the anterior surface of the lumbar body. The postcranial bones most commonly affected by treponemal disease are the tibia, clavicle, femur, ulna, hands and feet (Steinbock 1976; Aufderheide and Rodriguez-Martin 1998; Buckley and Dias 2002). Vertebral lesions due to treponematosis have been observed among some individuals although these are rare (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). However, the vertebral lesions associated with treponematosis are usually similar in appearance to lesions from tuberculosis usually involving the destruction of the vertebral bodies (Ortner 2003). One individual from New Mexico with treponemal disease had some sclerotic lesions on the ribs, although whether this is due to treponematosis or not is unknown (Marden and Ortner 2011). Nevertheless, since tuberculosis commonly affects most of the lower spine (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003), it is unlikely that this individual suffered from tuberculosis since only a single vertebra had lesions. Since the tibiae and fibulae were not examined and other postcranial bones did not exhibit any lesions indicative of treponemal disease, this diagnosis is still tentative.
Evidence of treponemal disease in Southeast Asia before the arrival of Europeans has not been reported so far. Yaws might have been present in the Philippines before European contact although syphilis is generally deemed to have been introduced to the Philippines and other parts of Asia by Europeans, particularly the Portuguese (Newson 1998; Newson 1999; Newson 2006). Previous researchers have reported evidence of possible treponemal disease on a skull from a cave in Samar, central Philippines although it is unknown if the individual lived before or during the colonial period (Borobia Melendo and Mora Postigo 1992).

**Burial 3**

The resorptive lesions on the vertebrae and vertebral ends of the ribs of individual 3 indicate a development of some form of disease on the thoracic region of the body. Diseases which leave skeletal lesions on the vertebrae include infections such as vertebral osteomyelitis, tuberculosis and brucellosis, or tumors.

Tumors on the vertebrae are rather rare and are commonly found on the anterior or posterior region of the vertebrae (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). Tumors commonly affect a single or two adjacent vertebrae (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). Osteolytic lesions with some new bone formation and ankylosis of adjacent joints are seen among individuals with tumors (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). However, individual 3 had mostly osteolytic lesions on the lateral parts of six vertebrae with little new bone formation, which makes it highly unlikely that this individual had tumors on the vertebrae.

Vertebral osteomyelitis is another rare condition and is rarely seen in skeletal remains (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). The lesions caused by vertebral osteomyelitis are also commonly localized to a single vertebra and affect at most the adjacent vertebrae (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). The spinous process and neural arches are most commonly affected by vertebral osteomyelitis unlike tuberculosis, where the anterior part of the vertebrae is usually affected (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldron 2009). Bony bridging of adjacent vertebrae and destruction of adjacent vertebrae is seen among individuals with vertebral osteomyelitis (Steinbock 1976; Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003). Since individual 3 had lesions on the lateral and...
anterior surfaces of the vertebrae and lesions were seen on more than two vertebrae, it is also unlikely that this individual suffered from vertebral osteomyelitis.

The presence of osteolytic lesions on the vertebral bodies and costal facets of the lower thoracic vertebrae along with resorptive lesions on the vertebral ends of several ribs of individual 3 is similar to the lesions commonly found in individuals with tuberculosis and brucellosis. Tuberculosis and brucellosis have similar manifestations on the vertebrae despite being caused by different types of bacteria. Lytic lesions on the vertebral bodies with no lesions on the posterior arches are characteristic of tuberculosis. Tuberculosis is commonly seen in skeletal samples since it is a disease of poverty, and can be transmitted to other people easily (Ortner 2003; Waldron 2009). Brucellosis is less commonly found in skeletal remains, and usually affects the hip and knee joints rather than the vertebrae (Ortner 2003; Waldron 2009). Since individual 3 is only represented by the vertebrae, ribs and some hand and foot bones, it is impossible to look at other postcranial markers of tuberculosis and brucellosis such as joint fusion on the hips and knees. The new bone formation on the anterior vertebral body of the 9th thoracic vertebrae is not characteristic of tuberculosis, since there is usually no new bone formation on the vertebrae of individuals with tuberculosis apart from the ankylosis of joints. Thus, the aetiology of the lesions from this individual is not as clear as that of individual 2212. Evidence of tuberculosis has been reported in prehistoric Southeast Asia (Tayles and Buckley 2004), and historical accounts have indicated that tuberculosis was most probably present in the Philippines before the arrival of the Europeans (Newson 1998; Newson 1999; Newson 2006). More concrete description of tuberculosis affecting Filipinos in the 19th century was documented (Newson 1999). However, no skeletal evidence of tuberculosis in the Philippines has been found so far.

**Adult Health**

This section provides the possible causes of the lesions found on the individuals from the two samples. The implications of these lesions on the health of past populations within the Philippine and Southeast Asian context are also discussed.

**Pre-colonial samples**

Two of the individuals from the pre-colonial samples had new bone formation on the distal joint of the first distal phalanges, indicating the presence of some form of joint disease. Individual T6 C57 also had pitting on the distal joint, which suggests the presence of degenerative joint disease. The distal joint of individual T4 C82 cannot be observed due to
the cement-like layer covering the bone. However, since individual T4 C82 is a mid-adult, it is possible that this lesion is also indicative of degenerative joint disease, since it is highly likely that individuals of older age develop DJD.

Individual T6 C144 had new bone formation on the shaft of the right femur which is possibly due to inflammation or infection (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martín 1998; Ortner 2003; Weston 2012). It is unknown whether the lesion occurred bilaterally since the left femur was missing, and no lesions were found on the tibiae and fibulae. Since no other lesions were found in other bones of this individual, it is rather difficult to assess the aetiology of this lesion. Interpreting periosteal reactions has always been difficult since these reactions can be caused by different infectious or metabolic diseases (Weston 2008; Weston 2012). However, periosteal reactions have largely been diagnosed as due to non-specific infections, although metabolic diseases can cause similar reactions (Weston 2008; Weston 2012). Thus, it is difficult to assess whether this lesion is due to an infectious or a metabolic disease. It is also possible that this lesion was because of trauma or ulcer (Resnick 1995; Ortner 2003; Waldron 2009; Boel and Ortner 2011). Based on the local environment and food resources in the area, it is more likely that these lesions were caused by an infectious disease, ulcer or trauma than a metabolic disease. Catanauan is mainly a jar burial site, although evidence of occupation such as shell middens and hearths were found (Paz 2008). The tropical environment in this area is ideal for the spread of vectors and pathogens of infectious diseases (Cook et al. 2003; Guerrant et al. 2011). Archaeological evidence from Catanauan and neighboring sites indicated that the people from this area had diverse food resources (Solheim 1951; Solheim 1954; Dizon 1979b; Dizon 1979a; Cuevas 1992; Paz 2008), thus it is less likely that they had poor nutrition which would have led to the development of metabolic diseases. However, since there are multiple factors involved in the development of periosteal reactions, it is also possible that this lesion is because of a metabolic disease.

Little evidence of oral pathology was found among the pre-colonial individuals, suggesting good oral health. Severe tooth wear was also absent. Archaeological evidence at the site includes extensive shell middens, although no evidence of plant cultivation has been found so far (Paz 2008). This suggests that these individuals had a diet composed mainly of marine foods with little cariogenic content. Thus, a low prevalence of oral pathologies is expected.
Compared to the individuals from the Metal period from other parts of Southeast Asia (Oxenham et al. 2002; Oxenham et al. 2006; Tayles et al. 2007), it seems that the individuals from the Philippines had less skeletal and oral pathologies. While skeletal preservation and sample size might have affected these results, it is possible that this discrepancy may be due to the differences in local environment and societal organization between continental and island Southeast Asia. The Metal period in continental Southeast Asia coincides with the development of the pre-colonial kingdoms which entailed the building of elaborate architecture for the elite and also for the mass production of food (Harrison 1955; Williams 1976; Taylor 1992; Osborne 2000). A different case was seen in island Southeast Asia as reviewed in Chapter 2. The lack of megalithic architecture in island Southeast Asia indicates a difference in lifestyle from the mainland. This might have had a positive impact on the health of island Southeast Asians since they were subjected to less stress than their counterparts from the mainland. However, the examination of more skeletal samples from the prehistoric period in island Southeast Asia is needed to assess the difference in health between the two regions.

**Spanish period samples**

Nine individuals from the Spanish period samples had skeletal lesions. Two of these individuals had very distinct lesions and were discussed in the previous section. All other individuals with skeletal lesions are discussed in this section.

The two individuals with remodelled cribra orbitalia had no other evidence of lesions. Both individuals were preserved fairly well although most of the bones were fragmented. The presence of cribra orbitalia suggests the presence of stress during growth. Cribra orbitalia has often been regarded as evidence of iron-deficiency anaemia since the lack of red blood cells cause the formation of spongy bone for red blood cell production, although clinical studies suggest otherwise (Ortner 2003; Waldran 2009; Walker et al. 2009). While cribra orbitalia can be an indicator of iron-deficiency anaemia (Oxenham and Cavill 2010), other aetiologies are also possible. Thus, some specialists have used cribra orbitalia as a non-specific indicator of stress as an alternative (Ribot and Roberts 1996; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Waldran 2009).

Four individuals had degenerative changes on the vertebrae, upper and lower limbs. While DJD was common among older adults in the Spanish period samples, the lack of DJD among the pre-colonial individuals suggests there was a difference in lifestyle and activities between the individuals from the pre-colonial and colonial period which increased the
possibility of developing DJD among the Spanish period individuals. Skeletal lesions on muscle attachment sites in the upper limbs of two individuals indicated the presence of enthesopathies. As reviewed in Chapter 2, enthesopathies are also used as indicators of lifestyle and activity patterns of past populations. The presence of these lesions also suggests stressful activity patterns among the Spanish period individuals which led to the development of these muscle attachment disorders. The Schmorl’s nodes found on the lumbar vertebrae of individual 2247 also indicate the presence of repeated stress. During the Spanish occupation, El Nido was part of the Taytay municipality in northern Palawan (Robertson and Blair 1993). A Spanish fort in Taytay, the Fuerza de Santa Isabel, was built in the late 1600s and finished in the early 1700s and was used as a military station by the Spaniards against Muslim warriors (Robertson and Blair 1993). The Santa Monica church inside the fort was also built at around the same time (Robertson and Blair 1993). As discussed in Chapter 2, forced labor was implemented among Filipinos under the polo y servicios policy for projects such as building churches and forts. It is possible that these activities have put the Spanish period individuals at higher risk in developing these joint diseases and enthesopathies, although more individuals need to be examined to confirm this.

Two individuals had proliferative lesions on long bone shafts. Individual 789, a young adult female, had lesions only on the right distal tibia while individual 2247, a mid-adult male, had lesions on both tibiae and fibulae. While individual 789 was slightly more fragmented than individual 2247, both individuals were preserved fairly well. No other pathology was found in individual 789. Individual 2247 had DJD on the cervical vertebrae, Schmorl’s nodes on the lumbar vertebrae, enthesopathies on the left clavicle and acromion process, bowing of both radii and new bone formation on the shaft of the right ulna. It is possible that the periosteal reactions from these two individuals are due to different causes. Since periosteal reactions were present bilaterally on the lower limbs and on the right ulna of individual 2247, it is possible that this individual had some form of systemic infection or metabolic disease (Rothschild and Martin 1993; Aufderheide and Rodriguez-Martin 1998; Ortner 2003; Brickley and Ives 2008; Waldron 2009). Since other individuals from the same site had evidence of systemic disease as discussed in the case studies section, it is likely that this person suffered from infection. However, evidence of poor nutrition among Filipinos during the colonial period also makes it likely for these lesions to be the result of a metabolic disease. The lesion on individual 789 was found only on the right tibia; hence it is possible that this individual suffered from a localized infection due to trauma or soft tissue infection rather than a systemic disease which affects the whole body (Rothschild and Martin 1993;
A higher prevalence of oral pathologies was seen in the individuals from the Spanish period compared to the pre-colonial individuals. Also, statistically significant differences in the prevalence of oral pathologies according to age and sex were found. An increase of oral pathologies with age is expected, however a high prevalence in young adults which decreased in mid-adults was seen. Also, a significantly higher prevalence of oral pathologies was found in females compared to males. This suggests a change in subsistence pattern from a more varied food source to a cheaper, surplus staple commonly seen among populations during the transition to agriculture (Cohen and Armelagos 1984; Larsen 1995; Jackes et al. 1997; Eshed et al. 2006; Cucina et al. 2011). When the Spaniards gained control of most of the lowlands, Filipinos were often hired to work the fields for minimal pay (Agoncillo 1969; Agoncillo 1990; Robertson and Blair 1993). The best harvest and animal produce were always reserved for the friars and the elite, while commoners had to make do with leftover resources (Agoncillo 1969; Roces 1977; Agoncillo 1990). It is possible that this might have caused the decline in oral health of the individuals from the Spanish period sites. However, the cause of the discrepancy in prevalence according to sex is unclear. While Filipino society during the Spanish period was mainly patriarchal due to the influence of the Spaniards (Agoncillo 1969; Agoncillo 1990), differential access to food according to sex were not documented. It is possible that the difference in the prevalence of oral pathologies according to sex is because of physiological factors such as changes in female sex hormones, biochemical composition of saliva and food cravings during pregnancy (Lukacs and Largaespada 2006; Vallianatos 2007; Lukacs 2008; Vieira et al. 2008).

The numerous lesions found on the Spanish period samples suggest that the individuals from this time period had poorer health than their pre-colonial counterparts. Historical evidence indicates that there was a decline in health due to the changes in lifestyle of indigenous Filipinos during the onset of colonialism (Newson 1998; Newson 1999; Newson 2006). The possible introduction of foreign pathogens to local populations is also likely to have contributed to the decline in health during the European contact period (Newson 2006). The prevalence of skeletal and oral pathologies from the Spanish period individuals show similar patterns seen in historical accounts.
Subadult Health

In this section, the health of subadults from the Spanish period samples is discussed since the single subadult from the pre-colonial sample did not have any lesions.

All of the subadults with skeletal pathologies had lesions on the lower limbs. All but one had proliferative lesions on both tibiae, although the individual with the lesions on the right tibia (individual 722) was missing the left lower limbs. Two individuals (individuals 2255 and 2249) also had proliferative lesions on the fibulae and individual 2249 had similar lesions on both upper limbs. Individual 1807 also had proliferative lesions on the cranium apart from the lesions on the tibia. All other individuals had no other lesions apart from those mentioned above. Among those with lesions, two were above six years of age while the rest were less than six years but over one year old. It is most likely that these individuals suffered from some form of systemic disease such as infections or metabolic disorders. These individuals probably acquired infections or suffered from malnutrition during the weaning period, particularly those less than six years of age. The weaning period is particularly stressful for young children due to the introduction of different nutrient sources which makes children susceptible to infections and malnutrition (Katzenberg et al. 1996; Sellen and Smay 2001). Evidence of the correlation between poor health among subadults and weaning has been found in past populations (Katzenberg et al. 1996; Sellen and Smay 2001; Oxenham et al. 2011). Studies on weaning practices in the Philippines are mostly from relatively recent periods (Zeitlin et al. 1978; Guthrie et al. 1980; Guthrie et al. 1983; Osteria 1983; Popkin et al. 1989; Abada et al. 2001) and reports on weaning practices during the pre-colonial or colonial period are scarce. These studies have mentioned that a relatively short breastfeeding period is usual particularly among the poor populations although this practice is thought to have been present only during recent times while a longer breastfeeding period was traditionally common (Jelliffe 1968; Zeitlin et al. 1978; Guthrie et al. 1980; Guthrie et al. 1983; Osteria 1983; Popkin et al. 1989). Rice water, apple juice and tea brews were used as folk remedies for infant diarrhea and solid supplements such as rice porridge, banana and applesauce were common infant foods (Jelliffe 1968; Simpson-Hebert and Makil 1985; Abada et al. 2001). These foods do not have much protein content which is important during weaning as it is a main nutrient responsible for growth (Jelliffe 1968; Abada et al. 2001). Also, solid foods were introduced later compared to other countries in Southeast Asia (Jelliffe 1968; Van Esterik 1985; Halcrow 2006). The knowledge of the importance of breastfeeding was evident among people from the Philippines, however, recent marketing strategies and modern health practices have resulted in a shorter breastfeeding period and an increased
reliance on commercially available infant formulas (Jelliffe 1968; Osteria 1983; Simpson-Hebert and Makil 1985; Popkin et al. 1989; Abada et al. 2001). It is possible that the poor nutritional quality of solid foods introduced to children during weaning resulted in the development of metabolic diseases.

Oral pathologies found in subadults from the Spanish period samples included circular caries on the deciduous dentition and alveolar resorption. Circular caries were most commonly found on the molars. Since deciduous teeth generally have a short lifespan, it is uncommon for caries to develop in deciduous teeth (Hillson 1996; Alt et al. 1998; Pietrusewsky and Toomay 2002). As discussed in Chapter 3, circular caries develop due to enamel hypocalcification when the enamel of deciduous teeth is poorly formed usually because of metabolic insults. This reflects poor maternal health since the enamel of deciduous teeth is formed in utero (Metcoff 1981; Halcrow 2006). As discussed in the previous section, historical accounts have mentioned that leftover staples were usually what the commoners were left with after the best crops and produces were taken by the elite (Agoncillo 1969; Agoncillo 1990). It is possible that poor nutrition of the mothers of these individuals led to impaired development of teeth which increased the risk of developing caries at such an early age. Also, linear enamel hypoplasia was found on the permanent dentition of individuals less than six years of age. None of the individuals over six years of age had LEH. This indicates some sort of stress among young children possibly due to poor nutrition during the weaning period (Goodman and Rose 1991; King et al. 2005). However, the relationship between weaning and enamel defects is not straightforward since other stress factors can also contribute to the development of these defects (Katzenberg et al. 1996).

The high number of child burials recovered from the Spanish period sites, particularly in Ille Cave is rather unusual for skeletal populations. This may be due to a misrepresentation of the burial population, since not all individuals from the site were examined, or there may be a high rate of child mortality within the population during this period. However, the examination of more individuals is needed to be able to assess with confidence the rate of mortality of this particular population. Subadult individuals from prehistoric samples in other parts of Southeast Asia were relatively few and did not have as many lesions as the individuals from this sample (Tayles 1999; Pietrusewsky and Toomay 2002; Domett 2004; Tayles et al. 2007). Thus, it is highly likely that the changes in lifestyle during the transition to colonialism had a negative impact on subadult health similar to the health of adults from the Spanish period samples. The combination of a tropical environment ideal for the spread
of infectious diseases and meager resources due to the impact of colonialism are important factors which had almost certainly contributed to the poor health of these people.

**Conclusion**

An examination of several skeletal samples from the Philippines has been accomplished to provide a representation of the health status of individuals from island Southeast Asia. The differences in environment and local history between continental and island Southeast Asia and how this has affected the lifestyle of the people living in these areas is a topic that has yet to be addressed. This thesis attempted to address this topic, and also the other gaps in knowledge regarding the past health and lifestyle of people from the region. This section discusses the aims of this thesis and objectives as well as topics recommended for further studies.

*Aim 1: To review the prehistory and early history of Southeast Asia, focusing on the bioarchaeology of the region and to identify where more research should be carried out*

This aim has been accomplished by providing a summary of important events in the prehistory and history of Southeast Asia, focusing on the expansion of the population which led to the formation of complex pre-colonial states and kingdoms and the changes in these states after the arrival of Western colonizers. A review of the bioarchaeological literature of Southeast Asia was also carried out, focusing mainly on the health and disease of past populations in Southeast Asia. As reviewed in Chapter 2, the bioarchaeology in Southeast Asia has greatly improved in recent years due to the numerous researches done on skeletal remains from archaeological sites dating to different time periods in Southeast Asian prehistory. Also, the review has shown the current gaps in knowledge in the bioarchaeology of Southeast Asia as well as the focus of archaeological research in different areas within the region. In continental Southeast Asia, the focus of bioarchaeological research is mainly on the prehistory of the area, particularly the health and lifestyle change during the transition to agriculture and the origins of the current population. This is mostly because the materials available for study are from the prehistoric period. A lack of interest in historical period archaeology as an alternative to historical studies also contributes to the lack of research in this subject. On the other hand, bioarchaeological studies in island Southeast Asia focus mainly on paleoanthropological research. The search for the earliest evidence of human occupation is the common topic of interest in island Southeast Asian archaeological research, with much focus on the earliest modern human fossils from the Philippines and Malaysia, and
the hominid fossils from Indonesia. Reports on skeletal remains from archaeological sites usually include descriptive accounts of the burials along with aging and sexing with no other information. Specialized bioarchaeological studies such as paleopathology and prehistoric health are rarely done. The lack of interest in bioarchaeological studies compared to other areas of archaeology, mainly due to the lack of specialists and the poor preservation of skeletal remains from these areas, results in a poorly-developed bioarchaeological research in island Southeast Asia. Studies on the changes in local life during the transition to agriculture in island Southeast Asia were very rare perhaps due to the difference in the history between mainland and island Southeast Asia. It is known through historical and archaeological evidence that the formation of large and influential kingdoms in continental Southeast Asia is mainly due to the population expansion which was enabled by the mass production of food through the adoption of agriculture (Bellwood 1978; Bentley 1986; Higham 1989a; Higham 1989b; Bellwood 1992b; Taylor 1992; Higham 1995; Higham 2002a; Bellwood 2005). However, a different case is seen in island Southeast Asia due to the different environment of this area. Maritime kingdoms were the norm in island Southeast Asia, where the seas acted as ‘highways’ for cross-cultural interactions and the expansion of these kingdoms (Spriggs and Chippindale 1989; Christie 1995; Spriggs 2000; Lape 2003). Bioarchaeological research on the changes in health of Southeast Asians during the transition to colonialism has yet to be done. Southeast Asia has a very varied and long history of colonialism by different European states and the influences of these colonizers are still reflected in the former colonies to this day. However, historical documents and archaeological data are the main sources of information regarding the historic period in Southeast Asia. A bioarchaeological perspective is needed to provide a more holistic picture of the historic past and it is important to start doing research to address these questions regarding Southeast Asian history.

This thesis attempted to address some of these gaps in knowledge of the bioarchaeology in Southeast Asia by examining skeletal samples from the pre-colonial and colonial period in the Philippines. A comparison of health in the prehistoric and historic periods is essential in understanding the past, along with other archaeological data which helps in acquiring a more holistic picture of past life in this region. While historical data focuses on pivotal aspects of the past such as the colonization of different countries in Southeast Asia, the lives of the influential people and the eventual independence of these colonies, little has been documented regarding the daily life of local people, and most of what has been recorded were usually done with an ethnocentric perspective. Looking at archaeological data provides an alternative which can be useful in confirming or refuting
historical sources. More ethnographic information on the prehistory and history of Southeast Asia is needed to assess the difference in the lifestyle of people during this transition.

**Aim 2: To assess whether or not there were any changes in health during the onset of colonialism in the Philippines and to begin addressing research questions regarding the prehistory of island Southeast Asia**

Skeletal remains from several sites dated to the late pre-colonial and early colonial period in the Philippines were examined to assess any difference in health status before and after the arrival of Europeans. Individuals from the pre-colonial site were dated to be from the late Metal period a few hundred years before the arrival of European colonizers in the Philippines. Very little skeletal and oral pathology was observed in the pre-colonial individuals due to the poor preservation of skeletal remains. On the other hand, a variety of skeletal and oral pathologies were seen from the Spanish period individuals, and more pathology was observed from females than males. This indicates a decline in health especially among females during the onset of colonialism, although a larger and better preserved skeletal sample particularly from the pre-colonial period is needed to confirm or refute this result and what sort of lifestyle and diet led to these sex-specific differences in health. Recent research on historic populations of former colonies has suggested a decline in health during the onset of colonialism (Larsen 1994; Klaus and Tam 2008; Klaus et al. 2009; Klaus and Tam 2009; Klaus and Tam 2010; Klaus et al. 2010). This thesis has shown that this trend is also apparent in the Philippines. Also, evidence of syphilis and tuberculosis were found among the individuals from the Spanish period. It is unknown whether these diseases were introduced to the local population by Europeans or if these diseases were already present in the islands before the arrival of the western colonizers, although evidence of tuberculosis has been found in prehistoric continental Southeast Asia (Tayles and Buckley 2004). However, historical accounts have stated that syphilis is most likely brought to the Philippines by Europeans (Newson 1999).

Bioarchaeological studies on prehistoric skeletal remains from island Southeast Asia are very rare and most focus on the study of fossilized early modern human and hominid remains. Studies on paleopathology and health of past populations in island Southeast Asia are very few and are usually available in local publications only. This thesis has addressed these gaps in knowledge of the bioarchaeology of island Southeast Asia by looking at the health of several skeletal samples from the pre-colonial and colonial period in the Philippines. Since the Philippines is one of the earliest colonized countries in Southeast Asia, any changes in health and lifestyle during arrival of Europeans would have been seen particularly among
individuals from the earlier colonial period. However, comparative studies are difficult to accomplish since bioarchaeological research on the health of people from similar time periods in other parts of island Southeast Asia are scarce. Thus, more studies on health of the prehistoric people of island Southeast Asia needs to be accomplished to assess any differences in the state of health of individuals from continental and island Southeast Asia.

**Aim 3: To provide a preliminary study of the state of health of past populations in continental and island Southeast Asia**

Although it is difficult to do a comparative study on the state of health of past populations in continental and island Southeast Asia due to the difference in the prevailing research interests in these areas, it is essential to do comparative research to assess the similarities and differences in health between the two areas. Continental and island Southeast Asia not only have very different local environments, the prehistory and history of these two areas are also quite dissimilar. The structure of complex states from continental Southeast Asia is different from states in island Southeast Asia. The differences in local environment have had a significant influence on the development of agrarian and maritime kingdoms in Southeast Asia. Also, the differences in definition as to what is considered as ‘prehistoric’ and ‘historic’ needs to be considered in comparative studies between mainland and island Southeast Asia.

In mainland Southeast Asia, no decline in oral health was seen during the onset of agriculture and the rise of the agrarian kingdoms, although an increase in the prevalence of trauma and disease was apparent (Pietrusewsky 1974; Houghton and Wiriyaromp 1984; Tayles 1996; Tayles et al. 1998; Tayles 1999; Tayles et al. 2000; Domett 2001; Pietrusewsky and Toomay 2002; Domett 2004; Tayles and Buckley 2004; Domett and Tayles 2006b; Douglas 2006; Oxenham et al. 2006; Tayles et al. 2007; Domett et al. 2011). Is a similar pattern present during the rise of maritime kingdoms in island Southeast Asia? The lack of available skeletal samples for comparison makes it difficult to assess if there was a difference in health of indigenous populations during the rise of kingdoms in continental and island Southeast Asia. However, the individuals from the Metal period in the Philippines seem to have lesser pathologies than their counterparts in mainland Southeast Asia. While preservation of the skeletal remains might have obscured any pathology of the individuals from the Philippines, it is possible that the people from island Southeast Asia had less pathologies and evidence of stress than those from the mainland. As discussed in Chapter 2, differences in the lifestyle of people living in continental and insular Southeast Asia were seen based on historical and archaeological information. Historical evidence suggests that
physical stress might have been more prevalent among continental Southeast Asians especially due to the construction of megalithic structures which was largely absent in island Southeast Asia apart from Indonesia (Williams 1976; Taylor 1992; Wolters 1999; Osborne 2000). It is likely that these dissimilarities would reflect a difference in health among the individuals from the two regions.

Further Studies

Several topics for further research on the bioarchaeology of Southeast Asia are recommended. A comparative study on the health of historic populations in other parts of Southeast Asia can be helpful in understanding the history of the region. Comparative research on skeletal samples from areas that had foreign presence but were not colonized such as Thailand and those that have been colonized can give us a better grasp of the effects of colonialism within the region. Were the people that were not colonized healthier than those that have been colonized? Were there age-related and sex-related differences in the state of health among those that were and were not colonized?

Also, a comparison of health among individuals from former colonies during the onset of colonialism is can be beneficial in understanding the impact of colonization. Studies on health of former colonies using historical data have found that the decline in health among Filipinos during the colonial period was not as severe as the decline in health in the Americas (Newson 1998; Newson 2006). Bioarchaeological studies on this topic would be useful in confirming this information and also to identify the possible reasons as to why the decline of health in the Philippines was not as severe.

A comparison of health between mainland and island Southeast Asia during the transition to agriculture and the rise of complex states and kingdoms is also useful in understanding the prehistoric past of Southeast Asia. Since these two areas within Southeast Asia have different local environments, resources and histories, differences in health between populations from continental and island Southeast Asia might have been present. A comparison of the health of individuals from continental and island Southeast Asia would enable us to understand the complexity of the interactions between nature and culture in a region with such diverse natural resources and cultural identities.
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**Ille Cave, Palawan**

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*Sex: 1 = male, 2 = female, 3 = unknown; Age: 1 = infant (<1 year), 2 = child (2-12 years), 3 = adolescent (13-18 years), 4 = young adult, 5 = mid-adult, 6 = old adult, 7 = unknown adult; Completeness: 1 = <25% complete, 2 = 25%-75% complete, 3 = >75% complete*
Ille Cave, Palawan (continued)

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Sibaltan, Palawan

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Bongabong, Oriental Mindoro

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Catanauan, Quezon Province

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